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SYMPOSIUM ON FOOT PROBLEMS CONFRONTED IN INDUSTRY, SCHOOLS, THE HOME, AND SPORTS

Introduction — HARVEY E. BILLIG, JR.
Developmental Anatomy of the Foot — JAMES J. MORROW
Arterial Supply of the Foot — ALBERT FIELDS
Venous, Lymphatic, and Autonomic Supply of the Foot — ALBERT FIELDS
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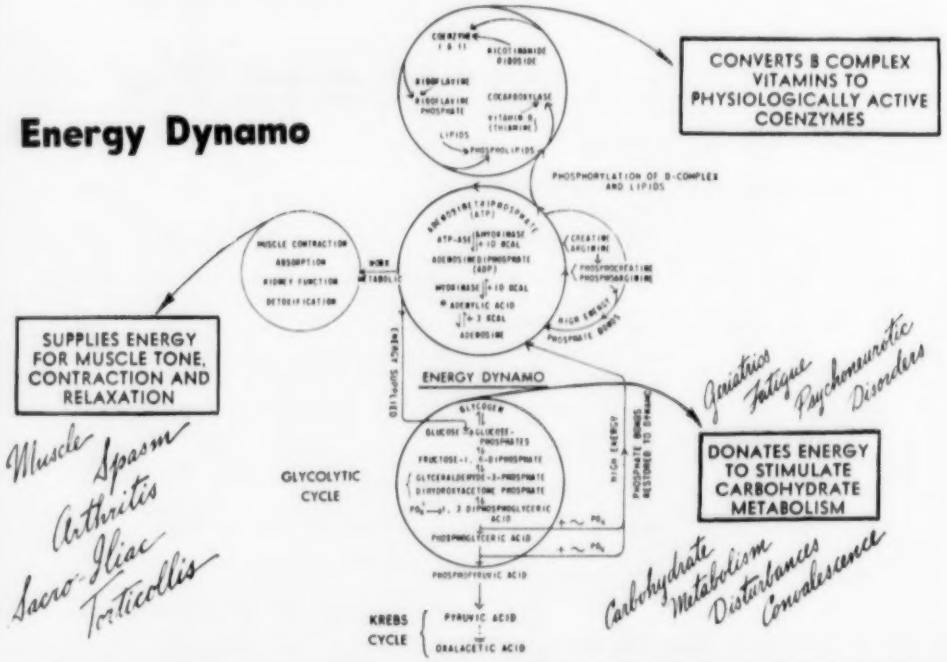

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SYMPOSIUM ON FOOT PROBLEMS CONFRONTED IN INDUSTRY, SCHOOLS, THE HOME, AND SPORTS

Introduction

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PROFESSOR OF PHYSICAL REHABILITATION, PEPPERDINE COLLEGE

LOS ANGELES, CALIF.

One of the basic physiologic "laws" is the requirement that every living organism be superior to its environment else it fails to compete and breaks down. The breaking-down process in the foot is very disconcerting, incapacitating, and painful since the use of the foot entails not only weight-bearing, but motion, coordination, and neurologic, vascular, and other satisfactory function. Proper development of the foot is primarily in response to genetic-hereditary, individual, family, racial, and phylogenetic characteristics. Superimposed on these are the acquired variations secondary to disease, injuries, habits, and customs of "encasement." Analysis of the effect of variations of all these interrelated factors on the function of the foot had best be sectionalized for organized presentation of a review of the subject.

In each of the following papers a prominent authority in his particular field discusses that field in relation to the function of the foot. This form of presentation was adopted with the view toward including the relationships of the foot to the body as a whole, rather than the foot as a separate entity, thus leaving with the reader a more comprehensive, functional, and hence useful knowledge.

Insofar as feasible, also included in the papers is the constant reminder that the foot is a dynamic physiologically functioning part of the body and not a static, unchanging entity.

The Symposium on Foot Problems Confronted in Industry, Schools, the Home, and Sports was held under the sponsorship of Pepperdine College, Los Angeles, and Billig Clinic for Habilitation, Los Angeles.

Developmental Anatomy of the Foot

James J. Morrow, M.D.

LOS ANGELES, CALIF.

Within the space limitations of this paper, it is impossible even to outline briefly the subject of the developmental anatomy of the foot. Therefore, the reader must accept statements that I shall make as facts founded upon science and its many branches. He must first accept the statement that once, early in man's history, there was an era when he used his foot as a grasping organ much in the manner still retained by the arboreal chimpanzee.

To conserve time, let us review a few observations to lay the groundwork for the previous statement. We begin with the Eusthenopteron from the Silurian period of the earth's time. This is the first of the lung-breathing fish, which developed bony and muscular fins that could help them to propel themselves slowly on land. Following, in the Silurian and perhaps into the Devonian period, came the "microbrachis," the short-armed, though even this transition may have taken 60 million years or longer. Then came the Seymouria, which can be classed as the first reptile or as the last amphibian, and was the first to lay eggs that could be hatched on land; during this period, Carboniferous, appeared also the subgroup of Cercopithecus (from *keros*, "the tail," and *podus*, "the foot") among the Crustacena, using the tail as an added means of land motion. Then followed the Cynognathus, the Carnivora, the dog, the fox, the wolf as the first mammals in the Triassic period of 180 million years ago. Then the marsupial family—the Didelphis—actually the only member on the North American continent being the opossum; then the Notharctus, the early Primates, the lemurs with their prehensile tails, then the Cebus or monkeys, and finally, only one and a half million years ago, man appeared; not as we know him now but as a prototype of modern man. And in each period and in each progressive stage, the foot changed as need or environment demanded.

Consider anatomic drawings of the feet of these mammals, from the marsupials (the didelphs) to man, and notice a few of the most noted evolutionary changes. In man, the great toe has undergone progression of growth; in the lower lemurs, the great toes have undergone regression. In man, the toes have become mere accessories of the sole of the foot, while in the three great living anthropoids, the orangutan, the chimpanzee, and the gorilla, the toes have become long, hooklike, grasping fingers. The changes that the human foot must have passed through in its progress from an anthropoid to a human status are numerous and varied, but whatever is the explanation, basically it must be that the origin of man's feet must be one that is likewise applicable to the feet of its structural allies, the gorilla, the chimpanzee, and the orangutan.

HUMAN EMBRYOLOGY

To understand some of the developmental problems of the feet of man, let us briefly review the embryologic development.

In a fetus of 5 weeks of fetal life and measuring 8 mm. in length ($\frac{1}{3}$ of 1 inch),

the arms and legs are simple protrusions. The distal ends of these protrusions flatten, and at 14 mm. (one week later) a constriction divides this paddle-like portion from a more proximal cylindric section (which will be the lower leg). One week later, at 18 mm., a second constriction separates the rounded part into further segments; the three divisions of thigh, leg, and foot are then marked off. Radial ridges first foretell the locations of the toes. One week later—at 25 mm. or the eighth week of fetal life—these ridges elongate into definite toes; the original plate, growing more slowly than the elongating toes, becomes the webs between the toes at their base.

The femur, tibia, and fibula each ossify from a primary center in the diaphysis and an epiphysial center at each end. Each tarsal bone ossifies from a single center. Each metatarsal and phalanx develops from a single primary center, but with an epiphysial center at one end. So that at 12 weeks of fetal life the entire bone structure is clearly outlined.

What is bone? It is a network of specialized connective tissue cells, called osteoblasts or bone formers, which form a screenlike tissue in whose meshes lime salt (calcium) is deposited—this is the basic rigidity factor of bone. There are actually two types of bone—though their mode of histogenesis is the same—those that develop directly within mesenchymal sheets and in general are the framework of the flat bones of the face and the skull; and the cartilaginous bones, which replace the earlier cartilaginous skeleton. This last type, being the one we are concerned with in the foot, will be outlined.

There must first be a destruction of the cartilage that exists primarily. In the center of this cartilage, these cells disintegrate and disappear, and cavities appear within the bone. At the same time, compact bone develops on the outside shell of the bone; this is the periosteum. Bones increase in length by the development of secondary centers of ossification in the ends of these bones; these are the epiphyses. Both surfaces of the cartilaginous plate, left between the original bone and its epiphyses, continue to develop new bone as long as the bone lengthens, and this in turn is replaced by bone matrix. But after childhood and adolescence (or whenever full growth is attained), the cartilage ceases to proliferate and the epiphyses are firmly united to the rest of the bone.

Centers of Ossification of the Bones of the Foot. The os calcis is the first tarsal bone to ossify; this begins at about 25 weeks of fetal life. Next is the astragalus, appearing between the twenty-fourth and thirty-second weeks of fetal life. The center for the cuboid bone is not seen until at least the fortieth week of fetal life, and may not be seen until after birth. (The ossification of this bone may be used to determine fetal maturity.)

In the phalanges, ossification centers begin to appear in the ninth week of fetal life, much earlier than in the tarsal bones. The first center is that of the diaphysis of the terminal phalanx of the first toe. The centers for the diaphysis of the metatarsal bones of the second and third toes follow almost immediately. At the tenth week, ossifying centers appear in the terminal phalanges of the second and third toes and occasionally the fourth toe. At the thirteenth week the terminal phalanx of the fifth toe may show a center as well as the basal phalanges of all the toes. At the twentieth week, the center of the middle phalanx of the second toe appears but

this may be delayed until even the twenty-fourth week. At the twenty-first week, the centers for the middle phalanx of the fourth toe may be seen. At the thirty-third to thirty-sixth weeks the center for the middle phalanx of the fifth toe appears. So at birth, we have a bone structure in the foot rather far removed from the adult bone structure.

DEVELOPMENTAL DEFECTS

Embryologic developmental defects are common. Some of the most frequent are clubfeet, supernumerary toes, overriding and underriding toes, metatarsus varus, giantism of the foot or parts thereof, absence of the entire foot (rare) or ankle (also rare), fusion of bones of the foot, etc.

Talipes equinus and *talipes varus* present three elements: plantar flexion, adduction, inversion; the cause may be a congenital subluxation of the astragaloscaphoid joint.

Talipes Calcaneovalgus. Here the foot is swung outward and the foot is in a heel-drop position. An anomaly of the astragalus is common.

Metatarsus varus, the pseudoclubfoot, is congenital and familial. The primary factor is a deformity of the proximal end of the first metatarsal bone. There is an angular divergence of the first metatarsal bone from the second, a wedging of either the internal cuneiform bone or the proximal end of the metatarsal, or the presence of a wedge-shaped "intermesial" bone, and the axis of motion in the tarsometatarsal joint is at an oblique instead of a transverse position to the long axis of the foot.

Morton's Syndrome. Factors of this developmental defect are (a) a short first metatarsal, which gives hypermobility of the first metatarsal bones due to unusually free motion in the joint between the inner cuneiform and scaphoid bones and between the inner and middle cuneiforms and (b) posterior displacements of the sesamoids.

Congenital Splayfoot. This is a congenital shortening of the first metatarsal bone with hypertrophy over the head of the first metatarsal bone, increase in mobility in the transverse arch of the foot, and an unusual degree of separation between the middle and inner cuneiform bones.

Congenital Flatfoot. Heredity is an important etiologic factor here. The paternal parent is more often responsible. An accessory scaphoid bone is frequently found. Congenital fusion of the scaphoid bone is frequently found. Congenital fusion of the calcaneus with the scaphoid and of the calcaneus with the cuboid may be found. Negroes are prone to have this particular congenital defect.

In conjunction with these osseous deformities of the foot it must be remembered that other deformities of a congenital nature, affecting the feet, may be caused by defects proximal to the foot itself. As an example, spina bifida, meningocele cord tumors, spinal cord pressure, and many congenital problems may give rise to non-functioning and malfunctioning feet, though the foot itself may not be deformed.

But whether the foot deformity is the result of congenital defects, developmental arrest, or hereditary factors, all are causes of an abnormality from the normal correct architecture of the foot. And a deviation from normal architecture gives cause for a weakness or distortion with a resulting loss of stability in bearing the weight of the superimposed body which together with the power of locomotion is the main function of our feet.

Arterial Supply of the Foot

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MECHANISMS OF ARTERIAL CIRCULATION

> The heart, consequently, is the beginning of life; the sun of the microcosm, even as the sun in his turn might well be designated as the heart of the world; for it is the heart . . . which . . . is indeed the foundation of life, the source of all action.
>
> —*William Harvey*

Improved investigative devices such as the direct writing electroplethysmograph are adding greatly to our understanding of peripheral arterial circulation and cardiovascular mechanisms. It is of interest that even before Harvey, accurate presumptions had been made as to some of the functions of blood circulation. In Shakespeare's *Coriolanus* (1609), when the starving citizens complained to Menenius, he described food distribution in terms of blood circulation:

> But, if you do remember,
> I send it through the rivers of your blood,
> Even to the court, the heart, to the seat o' the brain;
> And, through the cranks and offices of man,
> The strongest nerves and small inferior veins,
> From me receive that natural competency
> Whereby they live.—*Act I, Sc. 1*

The tremendous continual work performed by the heart is not generally appreciated. It has been calculated that every hour the heart puts out enough energy to carry a 150 pound man from the street to the roof of a three storied building. Every day the heart pushes around from 5 to 10 tons of blood (depending on the individual's size) through miles of blood vessels. In 70 years the average heart will have exerted so much force that if it were applied at one time it could lift the biggest battleship afloat 14 feet out of water. Every pound of excess weight adds many miles of blood vessels and greatly increases the load on the cardiovascular system. The daily flow in liters is presented by Miss E. A. Ullmann of St. Bartholomew's: thoracic duct, 3.1; digestive secretions, 8; renal glomerular filtration, 180; renal tubular reabsorption, 178.5; water loss through all channels, 2.5; cardiac output, 8 to 9000 (plasma, 5000); transudate into extravascular spaces, 7000.

Noting Schoenheimer's reference to the dynamic state of body constituents (1942) and Pomerat's demonstration of neurocellular water phagocytosis, Franklin has suggested that circulation be amplified to include the tremendous extravascular circulation. As expressed by Harvey's contemporary, Sir Thomas Browne (1605–1682): "Fly not only on the wings of Imagination: join Sense unto Reason, and Experiment unto Speculation, and so give life unto Embryon Truths and Verities yet in their Chaos."

DIAGNOSTIC AIDS

A detailed history and general examination usually provide some diagnostic leads. Venous tests are discussed elsewhere. The special examination of the lower extremities must include examination of the upper extremities and overlaps the locomotor-neurologic examination: gait, stance, and posture, range and ease of hip, knee, ankle, mid-tarsal, toe movements. Foot and leg coordination, repetitive movements, sensory tests, reflexes, special neurologic tests should be noted. Muscle atrophy, weakness, tenderness, fasciculations, foot abnormalities may be present.

Careful attention should be paid to the skin and its appendages, examining for atrophy, poor tone, scar adherence, poor healing of lacerations, excessive perspiration, effects of exposure to cold and dependence, and delayed return of color on pressure release. There may be poor nail growth, ingrowing fungi, or other infections. Venous filling time, strength of pulses, and angle of elevation for foot balancing should be checked.

Mention should be made of the diagnostic devices: oscillometry, plethysmographs, skin temperature recorders. There is increasing utilization of devices for measuring muscle work capacity (ergometers), tissue temperature, and sweating activity. The direct writing electroplethysmograph is particularly useful for evaluating potential collaterals by noting response to indirect heating, alcohol ingestion, posterior tibial or lumbar sympathetic blocks, and intra-arterial vasodilator injections. The use of radioisotopes is largely restricted to experimental laboratory studies.

Angiography (dos Santos, 1929) has opened new vistas for a direct approach to cardiovascular surgery. Among the contraindications are iodine allergy, poor renal function, very poor general condition, and impending gangrene. Some of the complications reported are local discomfort, transitory apprehension, air in the aorta, and temporary hypertension. Dye extravasation may be very painful and should be counteracted with regional injections of procaine hydrochloride and hyaluronidase. The few instances of femoral artery thrombosis reported in the literature are probably due to trauma and spasm of the diseased vessel and its collaterals rather than to the iodopyracet itself. Iodine reactions cannot be ruled out by absence of allergy history, previous injection without mishap, or negative skin tests. It is advisable first to administer an antihistamine and to inject into a vein 0.5 cc. of the dye solution. After waiting five minutes per cutaneous injection of the remainder of the solution (20.0 cc.) into the artery along with 1.0 cc. antihistamine, 5.0 cc. of 0.5 per cent of procaine hydrochloride and 2.0 cc. of vasodilator such as dehydrogenated ergot can be injected. Oxygen and syringes for adrenaline, antihistamine, and cortisone should be at hand. There is need for further improvement in radiopaque media and techniques.

SOME ARTERIAL DISORDERS IN FOOT PROBLEMS

> The blood flows continuously, like the current of a river, or the sun and the moon in their orbits. It may be compared to a circle without beginning or end.
>
> —*Ancient Chinese*

For some 50 centuries "pulse lore" has dominated Chinese medicine and the

medical care of hundreds of millions of persons. Philosophic concepts of the pulse and circulation are discussed in one of the oldest known textbooks of medicine, the *Nei Ching*, said to have been written by the Yellow Emperor, Huang Ti (c. 2698-2598 B.C.). The pulse was considered the manifestation of the status of the five viscera and the five elements, the expression of the yin-yang harmony, the ease or dis-ease of the body.

The pulse had been studied by the Hebrews and other ancient peoples. The Egyptians counted the pulse (c. 3000 B.C.) by means of a clepsydra or water clock. This was an earthenware jar of known capacity, perforated at the bottom with one or more small openings. From the quantity of water that escaped, the lapse of time could be roughly calculated. Even before Hippocrates (460-377 B.C.), the early Greeks counted the pulse and suggested that the arteries were filled with a vital spirit while only the veins contained blood. This belief probably resulted from their observation that after death the arteries were devoid of blood. Plato (427-347 B.C.) realized that the blood was in constant motion, but the concept of circulation and the true function of the blood was not grasped until centuries later.

Imhotep ("He who comes in peace") the presumed author of the Edwin Smith Papyrus (c. eighteenth century B.C.) had noted that the pulse and heartbeat were synchronous. This was apparently ignored until Praxagoras (c. 340 B.C.) of Cos; detailed studies were made by his pupil Herophilus (c. 300 B.C.) of Alexandria. He used the clepsydra and commented on frequency, rhythm, size, strength, and systolic and diastolic phases of the pulse. He described "pulsus caprizans" (? premature extrasystoles).

Erasistratus of Alexandria (c. 310-250 B.C.) was one of the first to contradict the concept that the arteries contained air and only the veins contained blood. He also postulated small communicating vessels from the veins to the arteries. Rufus of Ephesus (A.D. 98-117) confirmed previous observations that the pulse, heartbeat, and systole were coincidental. He commented on the pulse characteristics. He was aware that the movements of the fontanels in the infant were from arterial pulsations.

Bartolomeo da Montagnana, professor at Padua (1422–1441), described the irregular pulse associated with congestive heart failure. Nicholas of Cues (Cardinal Cusanus) (1401–1464) in his *Dialogue of Statics* (1450) referred to the counting of the pulse with the clepsydra. The pulse was used by Johann Kepler (1571–1630) in his astronomic timing and by Galileo Galilei (1564–1642) to determine the swing of the pendulum. From this Galileo developed the counting of the pulse by the use of a pendulum of known frequency. The pulsimeter or pulse clock was invented in 1625 by Santorio Santorio (Sanctorius) (1561–1636). The famed minute watch was constructed in 1707 by John Floyer (1649–1734).

It is apparent that long before William Harvey (1578–1657) the pulse had been studied and suggestions had been made as to the circulation of the blood. The Unitarian, Michael Servetus (1511–1553), had definitely described the lesser circulation:

> "The soul," says Holy writ, "is in the blood." More than this the soul is the blood. Then if the soul is the blood one must know how the blood is formed before arriving at any

conclusion as to how the soul is formed, and in order to understand how the blood is formed we must first know how it moves.

—*Christianismi restitutio* (Vienna, 1553)

There is no evidence that Harvey was familiar with Galileo's studies on hydraulics or with the writings of Leonardo (c. 1504), Amatus Lusitanus (1511–1561), Valverez (1556), Cesalpino, and other students of circulation.

As the heart dilates, the blood passes from the vena cava into the right ventricle where by contraction of the heart it is forced into the "arterial vein" and is thereby carried to the lungs where it is thinned out and becomes mixed with the air. From here it is passed into the venous artery which carries this blood, now thinned by air, into the left ventricle of the heart.

—*Realdo Colombo* (1516–1559): *De re anatomica* (Venice, 1558)

Harvey had learned about the venous valves from his teacher Hieronymus Fabricius ab Acquapendente (1537–1619), who had described the swelling of a vein distal to a ligature (*De venarum ostiolis*, 1603). There is an anecdote that one day Harvey in a contemplative mood was stroking his basilic vein. He noted that the blood was prevented in some manner from following the downward course of his finger. On release of the finger pressure, the blood immediately rushed to fill the empty vein. By successive repetitions of this procedure Harvey calculated the large amount of blood that was passing through this one vein. It was far too much for the liver to produce so rapidly and could be accounted for only by *circulation* of the blood. By ligating and cutting vessels he then demonstrated that both the arteries and the veins contained blood, even though he showed that the ebb-and-flow theory of Galen (129–200) was wrong. He presented these observations in his lectures of 1616 and in 1628 published the great classic *De motu cordis*. The slogan "malo cum Galeno errare, quam Harveii veritatem amplecti" was followed by the majority of his contemporaries. The support of René Descartes (1596–1650) and of the founder of the iatrochemical school, Franciscus Sylvius (1614–1672), gained acceptance of Harvey's theory during his lifetime and established scientific medicine.

TRAUMA IN PRE-EXISTING PERIPHERAL ARTERIAL DISEASE

Disability evaluation is not an exact science based on mathematical rules which will invariably produce the same conclusion irrespective of who operates the formula.

—*C. S. Schneider*, 1951

Many injured persons have pre-existing disease. In persons with vascular disease even minor injuries can prove very serious. The problem of evaluating the relationship between an injury and subsequent disability is often very complicated. For the purpose of this discussion the following definitions are presented: Disease: sickness, illness, or impaired function. Trauma: injury, direct or indirect; single, repeated, or prolonged blow, laceration, cold, heat, chemical. Peripheral vascular vessels: blood vessels of the extremities.

At the outset it should be pointed out that the vessels of the extremities are not independent entities. They reflect diseases and disturbances elsewhere in the body,

particularly in the cardiovascular system: cardiac, renal, cerebral, retinal. Disease in these structures can affect even normal peripheral vessels. Thus in cerebrovascular accidents or myocardial infarction, peripheral thrombosis may result from alteration in clotting mechanism or diminished peripheral blood flow. There may be embolization from mural thrombi produced by cardiac irregularities, mitral stenosis, or coronary thrombosis.

Blood flow in the extremities is directly related to circulation in the main vessels. Thus occlusion of the aorta or common iliac arteries reduces blood flow in the arteries of the lower extremities. Occlusion of the inferior vena cava or common iliac veins interferes with venous return from the corresponding extremity. An evaluation of the peripheral vascular system is incomplete without a careful history and consideration of the organs and structures mentioned. Special attention must be paid to the previous status of the skin and to the type of work. It is now recognized that pre-existing but nonsymptomatic Raynaud's disease may be initiated by vibrating tools. Excessive use of limbs in certain occupations usually presents a more difficult problem for evaluation of causal relationship.

If there is poor skin condition due to pre-existing venous or arterial impairment, a minor injury may produce very serious effects. The relationship between minor injury and the claimed production of major vascular disease usually presents a difficult problem. There often is dispute as to whether the alleged accident actually occurred. Another controversy may be created by the time interval between trauma and the appearance of resultant signs or symptoms. This time interval must be considered in relation to the condition of the circulation at the time of injury, the severity of injury, the presence of infection, and the time of institution of adequate treatment.

In evaluating peripheral vascular disease there is need for a detailed history, careful physical examination, and adequate laboratory and special circulatory tests. Specific inquiry must be made as to cardiovascular disease, symptoms, objective findings, and previous traumas and treatments. There is need for a detailed description as to the manner of the injury, the time interval before manifestation or change in symptoms, and the response to various treatments prior to this examination.

Prognosis is largely dependent on potential collaterals and prompt institution of proper measures to improve peripheral circulation and general health. Control of infections, coexistent cardiovascular disease, hypertension, diabetes, obesity, malnutrition, and anemia are vital. Correction of foot imbalance and shoe irritation and patient cooperation in adhering to diet, to foot and leg care, and to avoidance of tobacco are basic.

HEMORRHAGIC DISORDERS

Hemorrhagic disorders are uncommon causes of foot problems. A multiplicity of pathophysiologic theories and postulates have been presented to "explain" and classify the faulty mechanisms.

In most hemorrhagic conditions there is a defect in at least two of the three "hemostatic pillars": vascular wall, platelets, and coagulation mechanism. Vessel wall integrity depends on a complex dynamic state involving primarily cement substance

(requiring vitamins C, D, and K and calcium ions), balanced sympathetic innervation, pituitary-adrenal axis, and qualitative and quantitative platelet adequacy. Treatment depends on the cause. The major factors in some common disorders are here listed: hereditary hemorrhagic telangiectasia—congenital vessel weakness; vitamin C deficiency—increased permeability; allergic angiitis—increased permeability; thrombocytopenic purpura—quantitative platelet deficiency; thrombasthenia—qualitative platelet deficiency.

ARTERIOSCLEROSIS

The increasing incidence of atherosclerosis has been attributed to obesity, to diet high in calories, fat, and cholesterol and low in proteins, resulting in elevated plasma lipids, abnormal cholesterol phospholipid ratio, and increased lipoproteins. Diminution in plasma clearing factors, hormonal imbalance, and hypertension have been incriminated. It is felt that physical or emotional "stress" acting through neurohumoral mechanisms may be a significant factor in arteriosclerosis and many other diseases.

In the natural progression of peripheral arteriosclerosis, as the main vessels gradually become occluded, a compensatory blood supply develops through increase in size and number of collateral vessels. Eventually "vascular decompensation" may occur due to insufficient collateral reserve. The "last straw" may be a minor injury such as shoe irritation, an ingrown nail, or the stubbing of a toe, leading to tissue breakdown and gangrene.

The causal relationship between trauma and acceleration of arteriosclerosis is not always easy to demonstrate. A recent preinjury examination with a detailed description of circulatory status and skin condition is of value. The condition of the uninjured extremity may be an indication that "spontaneous" gangrene was not expected at that time in the natural course of the disease.

When a nonhealing wound or gangrene develops within two weeks after an injury, a causal relationship is very probable. When tissue breakdown or the appearance of symptoms is delayed, "acceleration" or "precipitation" is sometimes claimed, but the causal relationship is less certain. It can also be shown that many persons with similar arteriosclerosis without such an injury have lived for years with only slight disability. On the other hand, even minor injury, in the presence of inadequate treatment and infection, can lead to loss of limb or life.

DIABETIC ARTERIOSCLEROSIS

The vessel changes in diabetic arteriosclerosis are no different from those in nondiabetic arteriosclerosis. A diabetic extremity is more susceptible to the effects of injury than a nondiabetic arteriosclerotic limb or a normal limb. There is usually collateral reserve with low resistance to infection and impaired healing. When there is an unusual trauma with sudden aggravation of a diabetic arteriosclerosis, which previously had been under fair control, causal relationship is fairly obvious. There may also be aggravation or precipitation of the diabetes itself by stress.

> . . . we are struck by the fact that there is an extensive obliteration of the larger arteries and veins. Besides this, we find two other lesions which vary greatly in their intensity, namely, the periarteritis and arteriosclerosis.
>
> —*L. Buerger*, 1908

Gangrene in young men had been mentioned by Thucydides of Athens in 430 B.C. In 1879 Von Winiwarter noted inflammatory lesions in a leg amputated by Billroth, described the "endarteritis and endophlebitis," and referred to similar cases seen by Jaesche (1865) and others. In 1908 diseases known as presenile gangrene, spontaneous gangrene, local asphyxia of the extremities, and the Russian or Hebrew disease (Parkes-Weber, 1905) were established by Buerger as one clinical entity that he named "obliterating thromboangiitis."

The exact etiology has not yet been determined: there appears to be an inherent vascular sensitivity to tobacco, fungi, and other agents. Almost all the patients are young men, are heavy smokers (Erb, 1904), and have fungus infections of the feet. Thromboangiitis is rare in females and in Negroes; it is rare in the viscera and is uncommon in the upper extremities (Wilks, 1870).

Superficial migratory thrombophlebitis is a usual early sign (Laveran, 1894). With progressive arterial occlusion there develop foot pain, toe numbness, calf aches, and impaired walking ability. There may be increased sensitivity to cold with cyanosis on cold exposure and dependency, excessive perspiration, and impaired nail growth. Trauma may activate "resting" infection, produce excessive and prolonged vasospasm, and precipitate extensive thrombosis in a vulnerable vascular tree.

It is possible for a thromboangiitis obliterans extremity to have just enough circulating blood to maintain tissue integrity and create only minor symptoms. After injury, with continued smoking and foot neglect, the disease may be accelerated and aggravated. Increasing pain and disability lead to physical and emotional deterioration. With occlusion of vital collaterals, progressive gangrene and loss of limb are almost inevitable.

Treatment. In Samuels' new text there is an excellent discussion of conservative treatment. In the early stages adequate and continued treatment can arrest the disease and save the limb. Inflammatory reaction can subside and adequate circulation be re-established by development of collaterals and recanalization of thrombi.

The basic elements of adequate treatment are complete avoidance of tobacco, eradication of fungus infection, meticulous foot care, and measures to promote general health and local circulation. If the patient is cooperative and has stopped smoking, sympathectomy should be performed.

Samuels reports good results with hydration. Others advocate various autonomic-blocking agents and vasodilators, enzymes, hormones, and vaccines. For pain and gangrene these measures can be tried along with relaxants, nonopiate analgesics, alcohol, anticoagulants, femoral artery vasodilator injections, and nerve blocks with long-acting agents. These procedures, local débriding enzymes, and antibiotics can help avoid high amputation and provide a functioning extremity.

> Case 14: . . . every cause of excitement increases the pain. All the ordinary means of treatment failed, the pain getting worse rather than better, and visibly wearing out the man's health. Narcotic injections have done most for him, but their continuance of relief has depended upon their incessant repetition. . . .
>
> —*S. W. Mitchell*, 1864

Injuries anywhere in the lower extremity, not necessarily severe crushing or penetrating wounds or fractures but even sprains and apparently minor contusions, can result in causalgia (Greek *kausos*—heat, *algos*—pain). The basic mechanisms appear to be incomplete nerve injury and reflex vasomotor disorders with prolonged and severe pain and crippling sequelae from disuse.

The majority of cases seen today do not conform in every respect to Mitchell's classic causalgias. Under the heading of "major" causalgia are included traumatic angiospasm, reflex (sympathetic nervous) dystrophy, neurovascular reflex dystrophy, peripheral trophoneurosis, chronic traumatic edema, and posttraumatic osteoporosis (Sudeck, 1900). Traumatic neuralgia, posttraumatic finger syndrome, and "phantom limb" are usually classified as "minor" causalgias. Aside from severity of symptoms there is no real difference between the two groups. All these syndromes or symptom-complexes can be classified as posttraumatic vasomotor disorders.

The outstanding feature is pain: aching, throbbing, stabbing, tearing, or burning, beginning with the injury or hours to days later. There are often trigger points and usually aggravation by jarring, noise, blasts of air, dependency, manipulation, and emotional upsets. The patient may "guard" the extremity, holding a damp cloth against it. In the early stages there is usually vasodilatation with warmth, redness, and swelling. Later, the foot and toes become cold, cyanotic, sweating, atrophic, glossy, with fissures or weeping eczema. Occasionally Raynaud's phenomenon is prominent. There may be nonpitting edema of the foot with the toes smooth and tapering and impaired nail growth. Hair growth may be decreased, increased, or apparently normal. The joints become stiffened and painful and the muscles fibrotic and weak. Roentgenograms show varying extents of spotty decalcification and osteoporosis (Sudeck, 1900; Kienböck, 1901). These latter findings are aggravated by disuse. It is sometimes difficult to differentiate between posttraumatic osteoarthritis, myositis, and tenosynovitis.

For fuller discussions of the mechanisms of causalgia, reference should be made to the studies of Kuntz, Livingston, White, Smithwick, and Shumacker. Penetrating wounds and infections are usually ruled out as causative factors in civilian patients. More often there are crushing injuries producing central pain impulses in sensory fibers and to a lesser extent in somatic and sympathetic fibers. By reflex efferent impulses, the body attempts to minimize pain and trauma. Posttraumatic vasomotor disorders result from involuntary perpetuation of disorganized overactivity of the sympathetic nervous system along with an indirect influence on various glands, body fluids, the cardiorespiratory center, and the emotions, long after the original injury heals.

The establishment of "reverberating circuits" in the internuncial system of the spinal cord has been postulated. Repeated excitation of these intercommunicating neuron discharges stimulates at overlapping levels through the anterior horns, producing motor effects such as muscle spasm, with additional pain. When this overactivity is discharged through lateral (autonomic) horns, autonomic reactions are provoked.

Bayliss suggested antidromic (proximodistal) impulses along sensory fibers. Another theory involves the stimulation of efferent fibers, which accompany sensory nerves and have cell stations in posterior root ganglia (Ken Kure). Lewis discussed the excitation of a peripheral nerve plexus (nocisensor), which produces signs of inflammation through the liberation of a histamine-like substance. Tinel noted that section of an affected nerve distal to the point of injury may give pain relief (with paralysis and anesthesia). There has been considerable discussion of increased sensitivity of higher pain centers.

The most plausible theory for extremity causalgia is that of short-circuiting at areas of nerve injury with stimulation of adjacent afferent fibers by continuous flow sympathetic impulses. This concept does not, however, explain causalgia-like states where there are no continuous sensory nerves.

It has been suggested that the spotty bone changes were due to reflex vasospasm, failure of normal stimulation and disuse, hyperemia (Hermann, 1933; de Takats, 1945). In 1938 Sudeck presented a revised opinion suggesting "acute collateral transformation" as a normal regenerative process, a physiologic reaction to trauma.

Treatment. These patients are often labeled "litigation or compensation neurotics," malingerers, hysteriacs, psychotics, and constitutionally inadequate persons. Even though there may be psychogenic overlay and motives for prolonging disability, these terms are not justified, and various forms of psychotherapy, hypnosis, and electroshock are rarely indicated. Opiates and barbiturates too often lead to addiction and aggravation of emotional disorders. Adequate early treatment of the vasomotor disorder does offer hope for restoration of normal structure and function.

Proper treatment of the injury is basic: removal of residual foreign bodies, alignment of fractures, eradication of infection. Combinations of salicylates, nonbarbiturate, nonopiate analgesics, ataraxics, and sympathetic blocking agents should be tried. Prolonged lumbar sympathetic blocks, along with repeated injections of the femoral artery with a vasodilator such as dehydrogenated ergot, are suggested. These measures permit manipulations, massages with a vasodilator ointment, hydrotherapy, and exercises against increasing resistance. Early ambulation with elastic support and adequate limb protection are encouraged.

Scar excision, neurolysis, Tinel's section of nerve, and digital amputation are not recommended. The beneficial effects of sympathectomy have been presented by Leriche (1928), Evans, Morest, Shumacker, Abramson, and others. Mayfield advocates early sympathectomy regardless of the effects of sympathetic blocks. Once a vicious cycle has been established with pain engrams, prognosis is not good, and even spinothalamic tractotomy and excision of the sensory cortex may not provide pain relief.

Venous, Lymphatic, and Autonomic Supply of the Foot

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> The veins are extensible and expandible. . . .
> —*Leonardo: Fogli B. 10r.*, c. 1504

The word "vein" (Latin *vena*—vessel) appeared before 1400 in the old spelling "veyne." Leonardo (c. 1504) distinguished arteries "with two coats" from veins "with only one coat" (at times he used the term "veins" synonymously with "blood vessels"). The word "varicose" (Latin *varicosus*, French *varix*—tortuous), introduced by the "pulse-counter" Herophilus (335-280 B.C.), originally referred to any tortuous vessel. Venectus (Greek *ektasis*—extension) and phlebectasia (Greek *phlebs*—vein) are rarely used.

Venous disorders of the lower extremities are frequently aggravating to, aggravated by, or associated with foot problems. An understanding of these problems and of proper therapy necessitates a knowledge of venous anatomy. Reference should be made to the fine atlases of Grant and Anson. It is essential to be familiar with usual sites of branch vessels and communicators or perforators (Linton, Sherman).

The frequent anomalies and accessory vessels are better understood by reviewing embryology. The lesser (short, external) saphenous vein is the first extremity vein to develop in the embryo. As the postaxial vein of the hind limb bud, it originally empties into the internal iliac by way of the sciatic and gluteal veins. With thigh growth, the lesser saphenous vein develops progressively lower connections with the epifascial greater saphenous and later with the popliteal vein. After birth, the normal direction of blood flow is from the lesser to the greater and from the superficial to the deep systems, except in the foot.

MECHANISMS OF VENOUS RETURN

> The blood is squeezed out of capular veins into the little branches and from thence into the greater, by the motion of the members and the muscles.
> —*Harvey: De motu cordis*, 1628

In the three hundredth year since the death of Harvey (1578–1657) it is fitting to recall that the understanding of venous flow led to his concept of circulation. The vein valves had been described by Erasistratus the Alexandrian (c. 275 B.C.), Amatus Lusitanus (c. 1540), Canano (c. 1540), Vesalius (1543), Carolus Stephanus (1545), Sylvius (1555), and Riccolomini (1586). The elaborate study by Harvey's teacher at Padua, Fabricius ab Acquapendente (1574), probably led to his realization that Galen's ebb-and-flow concept was impossible in vessels containing valves and that the blood must circulate.

There is speculation that some ideas were appropriated by Harvey from Colombo (1559), Avicenna (980–1037), Cesalpino (1571), or Galileo Galilei, who was working on hydraulics at Padua while Harvey was a student (1600–1602). Harvey was probably not familiar with the illustrations of Leonardo, who had even referred to capillary veins in the skin and liver, or with the descriptions of pulmonary circulation by Ibn an-Nafis (*Epistle on the Perfect Man*, c. 1288) and by Servetus (*Christianismi restitutio*, 1553). Earlier descriptions of circulation in the horse are known to few cardiologists or even medical historians.

As early as 1670, Lower, the transfusionist, applied Harvey's writings to this problem and stated: "The blood is only driven from the lowest part of the body with difficulty through the impulse of arterial blood, and at times by the contraction of the muscles. . . ."

Wiseman (1676) also described the pumping action of the leg muscles aided by the venous valves. Von Rechlinghausen demonstrated (1906) that, when a person is standing, the force of the heart alone is inadequate to raise the venous blood from the feet to the heart level. This had been expressed by King in 1837:

> In some parts of the body, the force of gravitation returns the blood to the heart; and it might seem that elsewhere, as in the legs, the downward pressure of an arterial column serves to weigh against the inert column in the corresponding veins.

Venous blood pressure had been measured in the horse by Rev. Stephen Hales in 1733. In 1911 Hooker showed that exercise lowers the venous pressure in the foot. Carrier and Rehberg found (1923) that even slight involuntary movements reduced the venous pressure in the dependent leg. Warren and his associates showed (1949) that in normal persons the pressure in the saphenous veins falls on walking. Waters (1950) reported the venous pressure of the foot in normal persons standing still and erect as 100 to 140 cm. water (70 to 100 mm. Hg.), depending on the height. With leg exercise the pressure falls to 0 to 40 cm. water (0 to 30 mm. Hg.).

Barcroft and Dornhorst demonstrated (1950) the important role of the leg muscle booster pump ("peripheral venous heart"); with competent valves to prevent a reflux of blood down the legs, blood can be returned against pressures as high as 90 to 100 mm. Hg. Venous return is also aided by *vis a tergo* (Carson, 1815) by negative intrathoracic pressure during inspiration (Holman, 1950), and by compression of the iliac veins by increased pressure in the lower abdomen (Warwick, 1931; Franklin, 1937; Gatch, 1950).

Edema formation is related to venous return and capillary circulation. Our present-day concepts of the latter are based on Starling's theory of transcapillary equilibrium (1909) and the classic studies of Krogh (1928), Lewis, Landis (1928), and Drinker. Bauer (1950) depicted the lower limb vascular system as part of a large U tube, with permeable cross-connecting capillaries at the bottom of the U. Under normal circumstances, with each emptying of the left ventricle, some blood is introduced into the arterial side of the U tube and an equal amount returns and flows out of the distal end of the tube toward the heart.

At the arterial end of the capillary, where the blood pressure is maximal (45 mm. water), with the passage of fluid and small electrolytes (sodium and chlorine) into

the interstitial space, there is left an intravascular ultrafiltrate. Toward the venous end of the capillary, the hydrostatic pressure drops to 15 mm. water, while the elastic tissue tension and plasma oncotic pressure are increased, with resultant reabsorption into the capillary of fluid with sodium chloride and sodium bicarbonate.

The normal erect individual is constantly on the verge of edema. This tendency is promoted by increased hydrostatic pressure as in standing still for prolonged periods, by hypoproteinemia (Leiter, 1931), and by increased capillary permeability from slowed circulation and local hypoxia. With leakage of protein into the tissue spaces, there is a further lowering of intracapillary osmotic pressure with further fluid exudation, creating a vicious circle. Edema is more likely to develop during hot weather, in the obese, and in those with renal malfunction and hormonal imbalance (thyroid and corticosteroid). Increased interstitial fluid causes interference with tissue metabolism and subcutaneous and skin changes with fibrosis and possible breakdown.

VARICOSE VEINS

> When the veins become old they lose the straightness of their branchings and become more folded or tortuous and the covering thicker as old age increases with the years.
>
> —*Leonardo: Fogli B. 10r.*, c. 1504

Probably the most common disease requiring surgery is lower extremity varicosities—found in more than 10 per cent of the general population. For persons more than 40 years of age the incidence is 72 per cent in women and 40 per cent in men. Although rarely a threat to life, the complications of varicose veins impose great annoyance, with restriction of activities and a considerable cost in terms of medical care and man-hour loss.

Hill, who described lower leg lesions in birds, noted: "the mechanics are rather different here in view of the less 'meaty' pelvic limbs." Zoologists and veterinarians have informed me that varicose veins and their complications are rarely seen in animals, not even in anthropoid apes, despite their orthograde posture; probably leg shortness, as compared to leg length of man, is a factor.

It has been generally accepted that incompetent valves (Edwards, 1935) were the basic factors in most varices—85 per cent. Dilatation without apparent valve failure occurs in only 15 per cent. There is said to be a congenital valve and vessel wall weakness in 70 per cent and a high familial incidence (55 per cent). This writer feels that more attention should be paid to inefficiency of the leg muscle pump and to activation of arteriovenous shunts. In most instances there are a number of contributing factors: sex, age, familial; obesity and dietary deficiency; obstruction—pregnancy, pelvic tumors; inefficiency of leg muscle pump—poor foot balance—prolonged standing with little movement; postthrombophlebitis; arteriovenous shunts; (spider bursts).

Many persons with large and extensive varices are relatively symptom-free. In others the symptoms are due not to the varices, but to associated "foot strain,"

fibrositis, arthritis, nerve root pressure, or peripheral arterial insufficiency. The chief complaint is usually cramping or aching foot and leg pain due to increased blood volume in the leg. There is a sense of heaviness, aggravated by prolonged standing, worse toward the end of the day and eased by elevation or elastic support. Fatigability, paravenous pain and paresthesias, and nocturnal leg cramps vary with individual hypersensitivity. Pruritus and tenderness are usually related to stasis dermatitis (varicose eczema) and ulcerations. Cyanosis, edema, and severe pain occur with postthrombophlebitis.

Tests. Reverse blood flow in a varicose vein was demonstrated by Brodie in 1846. A variety of tests are now available for superficial, deep, and communicator vein incompetence, saphenofemoral (Brodie-Trendelenburg, 1891), tourniquet-walking (Perthes, 1895), compression-walking, multiple tourniquet (Mahorner-Ochsner, 1936), tourniquet-bandage (Pratt), percussion (Schwarz-Heyerdale, 1940). There is need for simplification of phlebography (Dos Santos, 1938; Felder, 1950) and standardization of techniques and interpretations. In valve incompetence, venous pressure is higher, the walking drop is not as great, and the return elevation occurs in a few seconds. Venous pressure testing is a simple office procedure and should be used more extensively (Pollock, 1949).

Varices should not be considered as entities in themselves. Attention is called to the high incidence of obesity, dietary imbalance, enteroptosis, hemorrhoids, hernia, varicocele, pelvic infections and tumors, poor leg muscles, foot fungus, and imbalance. Every patient merits a complete history, basic laboratory tests, and physical examination, including pelvic, rectal, and detailed locomotor-neurologic-vascular examinations.

Cardiac disability and even decompensation are no longer considered contraindications but rather indications for varicose vein surgery. Pooling of blood in varicose veins can cause dyspnea, dizziness, and precordial distress. Even in the supine position, there is an additional strain on the heart from the increased blood volume and generalized increase in venous pressure.

Treatment. Too often varices are injected or even operated on with neglect of aggravating factors or other conditions that may be responsible for the lower extremity disabilities. Special attention should be paid to reasons for failure of the leg muscle pump. Patients with mild cases and those awaiting surgery should be started on an improved diet and on measures to improve peripheral circulation, and should wear elastic support.

Phlebectomy. The surgical treatment of varices has gone through several cycles since the multipuncture of Hippocrates (c. 400 B.C.) and Galen's hook evulsion (c. 200). An extensive historical review of this interesting subject has been presented elsewhere. Vein surgery, like all modern surgery, was made practical by Lister's antisepsis (1865) and sterile ligatures. Excision of the long saphenous veins, described by Albucais (1106), was reintroduced by Madelung (1884) and Schede (1887). Stripping was introduced by Kellar (1905), Charles Mayo (1906), and Wayne Babcock (1907); the technique of the last is still used after half a century.

High ligation was described by Celsus (A.D. 25), Paulus Aegineta (1690), Paré (1790), and Trendelenburg (1891). Present-day surgery is based largely on the work

of Homans (1916) with high ligation and removal of the long saphenous vein or multiple excision ligations of the communicators. With preliminary sedation, the ligations and stripping can be performed under local anesthesia. The long saphenous vein must first be divided close to the saphenofemoral junction along with all of its branches and accessory vessels. A Myers intraluminal stripper is inserted at the medial malleolus and the entire vein is removed from the ankle up to the groin.

In many instances internal stripping is impossible because of excessive tortuosity or skin adherence and occlusion from previous inflammations or sclerosing agents. In these patients, multiple incisions are made for external stripping (Mayo) or excisions of the vein with subfascial ligation of all incompetent communicators. Even when there does not appear to be any involvement of the lesser saphenous system (90 per cent), the likelihood of recurrences is reduced when this vessel is ligated in the politeal region and is stripped out from the lateral malleolus proximally.

The leg is wrapped with an Ace bandage over mechanics' waste and the feet are elevated on two pillows. The patient is encouraged to take slow deep breaths, do repeated foot-stretching exercises, and drink fluids freely. Despite groin discomfort the patient must be out of bed the same afternoon (not sitting), walking around for five minutes of every two hours. Continued foot and leg care, wearing an elastic support for three months, and follow-up sclerotherapy every six months are mandatory.

Sclerotherapy. In 1845 Francis Rynd of Dublin reported injections with a trocar-cannula. The chemical obliteration of varicose veins began with the discovery of the hypodermic syringe by Pravaz (1851) and his use of 30 per cent ferric chloride, and Alexander Wood's adaptation of Ferguson's syringe (1853). Frequent vein obliteration had been observed in the treatment of syphilis with mercuric chloride, and in 1911 P. Linser developed the use of a 1 per cent solution for the injection of varices. A detailed review of sclerotherapy, with the various solutions and techniques, has been presented elsewhere.

Kretzschmar introduced sclerotherapy into the United States in 1924. Through the advocacy of McPheeters, Dixon, de Takats, and Mahorner, for two decades this was the most popular form of varicose vein therapy in this country. In recent years there has been a loss in favor because of the recurrences and reactions. Disability has often been increased by injection of excessive solution and sclerosant action on communicator and deep veins. Injections outside the veins have resulted in local thrombophlebitis, lymphangitis, ulcers, and scarring; prompt injection of hyaluronidase-hydrocortone–procaine hydrochloride may be protective.

In most centers sclerotherapy is now restricted to spider bursts and venules missed at or appearing after surgery, using foam (Ohrbach) or 1.0 cc. of dilute sclerosant.

Postthrombotic. Piulachs has suggested that superficial varices appearing after deep thrombophlebitis are due not to back pressure and valve destruction, but to activation of latent arteriovenous fistulas. Even with deep incompetency, it is usually advisable to eliminate the pooling of blood in large subcutaneous reservoirs by stripping and multiple ligations. At the same time, the venous ulcer that has resisted conservative therapy can be excised and a skin graft applied. In many instances, ulcer

excision will reveal a deep "feeder" vein that has prevented ulcer healing. Sclerotherapy should be reserved for residual venules after surgery.

Arteriovenous Shunts. Everyone has multiple, small, congenital arteriovenous shunts (Sucquet-Hoyer canals) in the lower extremities as well as throughout the body. According to Piulachs and Vidal-Barraquer (1953), all varices originate from activation of these arteriovenous shunts by hormonal, traumatic, static, and other forces. Contrary to the impression of most writers, they do not consider postphlebitic varices as compensatory, but rather as the results of dilatation of arteriovenous fistulas due to phlebitis. Pratt (1949) recognized this in 25 per cent of his patients. According to this concept, superficial veins receiving blood at high pressure become dilated and there is secondary valvular insufficiency. By retrograde transmission of increased pressure in the veins, distal tissue changes are produced. This theory is supported by the following observations in varicose patients: rapid visualization of the venous system after arteriography, demonstration of competent valves by retrograde phlebography, high oxygen content of varicose vein blood, reduced circulation time from femoral artery to tongue, demonstration of arteriovenous fistulas by surgery and postmortem injection specimens.

Spider Bursts. Even in the absence of obvious varices, small venules and spider bursts are frequently seen about the ankles and other parts of the lower extremities. These should be differentiated from arterial spider nevi, also known as nevus arachnoideus and tache stellaire étoile vasculaire. These cutaneous arterial spiders, originally described by Erasmus Wilson in 1869, were erroneously considered by Osler to have veins in the "legs" bringing blood to the center of the nevi. They always occur in the upper part of the body and are related to early pregnancy, infectious hepatitis and other liver diseases, and vitamin B deficiency of pellagra.

An attempt has been made to differentiate lower extremity "angiectids," small, raised, circumscribed intradermal masses of bluish vessels. According to Fried and his co-workers, angiectids were present in 10 per cent of clinic patients, nine times more frequent than saphenous varicosities. In their series, estrogen therapy usually provided relief of pain and disability.

Many of these cosmetic blemishes can be eradicated by injections of feeder venules with 0.2 ml. 3 per cent sodium tetradecyl sulfate in 1.0 ml. 1 per cent procaine or with sodium tetradecyl sulfate foam (Ohrbach, 1950). A 30 G needle, strong light, magnifying light, and a steady hand are required. Barrow prefers electrocoagulation. There is need for further evaluation of hormones, tissues, vitamins, rutin, bioflavonoids, and hesperidin compounds.

The larger varices of pregnancy should be treated by heavy elastic stockings, increased periods of leg elevation, and foot and leg exercises. Measures for improving peripheral circulation and general health and postponement of stripping until two months after delivery will reduce the likelihood of complications and provide better results.

ACUTE SUPERFICIAL THROMBOPHLEBITIS

Superficial thrombophlebitis usually follows trauma, infections, and injections.

There is greater incidence in varicose veins, especially when using sclerotherapy. In the absence of these obvious causes, the condition should not be considered as benign and idiopathic without investigation for visceral malignancy and adequate blood studies.

Treatment. There is disagreement as to the best treatment. If there is no deep vein involvement, pulmonary embolism is not a problem. Small localized areas can be treated by perivenous injections of procaine penicillin with hyaluronidase or by excision of the involved segments under local anesthetic. Excision of the entire vein by external stripping (Hermann, 1952) or multiple incisions, using "protective" antibiotics, decrease disability and complications.

ACUTE DEEP THROMBOPHLEBITIS AND PULMONARY EMBOLISM

> . . . there were old coagula filling many of the branches of the pulmonary artery. In this case there were also several large, solid, fibrinous masses in the substance of the lung; . . .
>
> —*W. S. Kirkes*, 1852

The incidence of venous thrombosis continues to increase despite extensive programs of prevention. Since the pioneer studies of Virchow and Cohnheim, a great deal has been learned about intravascular thrombosis, as indicated by the writings of Nygaard (1941), Quick, and Wright.

Prevention. There is need for simple, accurate measures of identifying potential "clotters" and instituting measures to combat increased blood coagulability and venous stasis. The likelihood of thrombosis is increased in lower extremity fractures, surgery, and crushing injuries, in extensive pelvic or abdominal surgery (malignancy), in pregnancy (Chapman, 1864), and in prolonged bed rest for cardiac decompensation and other reasons. There is a high incidence of "clotters" in persons more than 50, in those who are obese, who have varicose veins, previous thrombophlebitis, anemia, infections, "weak feet," and a family history of thrombophlebitis. Incidence, morbidity, and mortality in the presence of various factors have been reviewed by Byrne (1956).

In these potential candidates, whenever possible, the aggravating factors should be removed prior to surgery or promptly attended to when there will be enforced bed rest or pregnancy. Too often no attention is paid to dietary deficiencies, obesity, foot fungi, and imbalance.

During surgery, tissues should be handled gently, knee supports should be well padded, and leg pressure avoided. Venous stasis is minimized by written orders forbidding heavy sedation, tight abdominal binders, or bent-knee position with popliteal pressure in or out of bed. Properly applied compression bandages or elastic stockings (Wilkins, 1952), repeated deep breathing, foot and leg exercises (Ochsner, 1947), pushing on a footboard, attention to bowel and bladder with avoidance of distention and straining, and early ambulation are essential. It is now generally felt that prophylactic superficial femoral vein ligation is no more effective than anticoagulants (Allen, 1947).

Massive pulmonary embolism is the chief factor in more than 3 per cent of all hospital deaths. About 50 per cent of deaths are without clinical warning. For the 50 per cent of patients who survive an initial episode of pulmonary embolization, available treatments are very inadequate. The Trendelenburg embolectomy (1908) carries a 90 per cent mortality.

There is no practical distinction between silent (Homans, 1934) phlebothrombosis (Ochsner and DeBakey, 1941) and thrombophlebitis (phlegmasia alba dolens). Both can be present in the same leg or even the same vein, and one form can change into the other. Before pulmonary embolization occurs, this diagnosis should be suggested by fever, rapid pulse, and leg pains and confirmed by leg measurements, calf tenderness, distended superficial veins, and positive Homans and Lowenburg tests.

Treatment. Some advocate prompt ligation of the superficial femoral vein flush with the profunda entrance. If there is proximal or bilateral involvement or pulmonary embolism, inferior vena cava ligation is advisable. Probably the routine most widely used, especially after 48 hours, is bed rest, extremity elevation, hot packs, and anticoagulants (Allen). Leriche has emphasized the role of reflex stimuli with collateral arterial and venous spasm, leading to local venous hypertension, increased capillary permeability, and the production of tissue anoxia and pain. The therapeutic value of sympathetic blocks has been adequately demonstrated by Ochsner and DeBakey, despite the contrary views of Goetz (1950) and Allen (1955).

Anticoagulants present some risks and prohibit repeat blocks. It is safe to use acting anesthetics or repeat procaine injections through a fine plastic tubing.

In conjunction with these procedures the femoral artery has been injected repeatedly with a vasodilator (and at times with heparin, trypsin enzyme, and antibiotics). To avoid postthrombophlebitic syndrome and acute exacerbations, early ambulation with elastic support, continued foot care, foot elevation for five minutes of every two hours, massage, exercises, and various measures for improving peripheral circulation and general health are essential.

POSTPHLEBITIC SYNDROME

> The postphlebitic syndrome is a devastating disease characterized by an insidious progression from minor swelling of the leg to massive ulceration, incapacitation and economic collapse.
>
> —*Wayne Co. G. H. Exhibit*, 1956

More than one-half million people in the United States suffer from this crippling disease; of these, 25,000 are totally disabled. In terms of loss of employment and hospitalization, the cost of each case runs into many thousands of dollars.

The underlying etiology is acute thrombophlebitis of the deep veins, usually traumatic. About one third of the cases seen by me occurred after fractures of the tibia, femur, or pelvis. The basic pathology is deep vein thrombosis coexistent with a varying degree of inflammatory reaction, involving the veins, venous valves, perivenous tissues, and lymphatics. When the infection subsides, even with recanalization, there is distal venous hypertension. Transudation of protein-rich fluid into the

surrounding tissues leads to fibrosis and induration of the overlying skin. For purposes of discussion, three stages are presented.

1. *Symptom-free Stage.* There may be an absence of symptoms for months to years after the acute episode depending on location and extent of thrombosis and degree of inflammatory reaction, adequacy of treatment of the acute phase, precautions during the symptom-free period.

This is the stage of education when the patient should be seen at least once a month. Corns, calluses, blisters, fungus infections, and other "minor" foot disorders should receive prompt attention, preferably in cooperation with a competent chiropodist. For fungus infections, only mild preparations such as weak potassium permanganate soaks and undecylenic acid compounds can be used.

2. *Edema.* Along with pain, swelling is the chief characteristic of acute deep thrombophlebitis. A few weeks or months after the acute phase, the edema reappears in those who are inadequately treated or neglected during the symptom-free period. Hot weather, local trauma, prolonged dependency, increased sodium intake, or pregnancy is often a precipitating factor.

Initially, the foot and leg edema is pitting and clears on bed rest or elevation. The edema is associated with heaviness, aching, increased fatigability, and ankle and foot stiffness. There may be local warmth and distal coldness with increased perspiration, increased cold sensitivity, elevation pallor, and cyanosis on dependency or exposure to cold. Pain and night cramping interfere with sleep; prolonged barbiturate and opiate intake lead to depression, irritability, and poor cooperation.

The reappearance of swelling is a grave prognostic sign heralding the onset of chronic venous and lymphatic insufficiency. Prompt and specific care is called for: bed rest, foot elevation. The patient must wear either a properly fitted stocking or an elastic support for the rest of his life, bandages snugly applied in the morning before leaving the bed. The best bandages are 4 inches wide, elastic reinforced with rubber. Scott's air-pressure legging (1949) has some advantages. Women prefer stockings; unfortunately, those that are not obvious are inadequate in their supporting action. Several sets of bandages and stockings should be available for alternate wearing and frequent washing; they usually last about four months.

To all my peripheral vascular patients I give detailed written foot care instructions. Patients with postphlebitic syndrome require additional indoctrination in what Luke calls the "new way of life." These patients must learn to live with and minimize their residual disability. They must realize that the postthrombotic leg will never be normal and that future activities or disabilities will depend on cooperation. Every hour, at work or at home, the leg should be elevated for five minutes of foot and leg exercises and massage. There should be mid-morning and mid-afternoon 30 minute rest periods for removal of the bandages, leg exercises, manipulations, and massage with a vasodilator ointment followed by bland dusting powder.

During the day, whenever possible, the legs should be held horizontally, especially on long automobile, train, and airplane trips. During the night, the foot of the bed should be elevated on 6 inch blocks. Aching night pains may be eased by aspirin, antihistamines, or quinine, 300 mg.

3. *Chronic Venous and Lymphatic Insufficiency.* This is the sad stage of neglect. With

recurrence of infection from minor trauma and inadequate foot hygiene, there is progression of the disease. This leads to fibrosis, pigmentation, ulceration, cellulitis, compensatory superficial varices, induration, and sometimes massive edema.

It may be possible to evaluate deep venous and communicator circulation by various tests. If the patient is able to walk about with an elastic bandage for 30 minutes, the deep venous circulation can be considered adequate. When the superficial fibrosis is too extensive, venous pressure may be a guide. Normally, the venous pressure in the lower leg falls 40 to 50 cm. water with ambulation. In advanced postphlebitic syndrome, the leg pressure may rise in spite of ambulation. Phlebography is extensively used in some centers. Luke uses retrograde phlebography, while others prefer injections of the radiopaque dye from below, compressing the superficial veins with bandages or elastic stockings.

Treatment. Many physicians do not have the time or interest to treat these unfortunate people adequately. The pessimistic attitude has led to large settlement from insurance companies when the condition is related to an accident. Unfortunately, the patient is also left physically and economically incapacitated. Individual care, persistence, and patient cooperation are basic.

If there is actual cellulitis or reactivation of acute thrombophlebitis, bed rest with leg elevation, continuous warm saline applications, and specific antibiotics are instituted. There is often associated vasospasm with sympathetic overactivity. Arterial flow and venous return can be improved by local and indirect heat, hydromassage, muscle relaxants, and autonomic blocking agents. These procedures, along with repeated femoral artery vasodilator injections, are continued when the patient becomes ambulatory on his "new way of life."

Sympathectomy. The sympathetic chain and ganglia had been known since the time of Galen, who originated the idea of "sympathy" or "consent" between all parts of the body. In 1727 Du Petit described the origin of the sympathetic trunk below the cranium and observed the pupillary changes after cervical sympathectomy. In 1815 Dupuy noted warmth and sweating of the head of four horses after section of their superior cervical ganglia. The function of opposing vasomotor nerves was first clearly presented by Bernard in the rabbit's ear in 1849–1851, in the tongue in 1853, and in the submaxillary gland in 1858. Ludwig suggested that vasomotor nerves were of primary importance in maintaining vascular tone and blood pressure.

The first cervical sympathectomies were performed for epilepsy (Alexander, 1889; Jonnesco, 1896) and for exophthalmic goiter (Jaboulay, 1899). Based on Francois-Frank's postulation of visceral afferent fibers (1899), Jonnesco removed the stellate ganglion for angina pectoris (1916). Urged by Kraus, Bruening performed a stellate ganglionectomy in 1923 for hypertension with angina.

Sympathectomy for peripheral vascular disease largely resulted from the work of Leriche. Periarterial sympathectomy for peripheral vascular disease, suggested in 1899 by Jaboulay, was introduced by Leriche in 1913. Leriche, with Kunlin, described beneficial results in a variety of peripheral vascular diseases from sympathectomy. Hunter and Royle (1924) applied this to spastic paralysis. During the 1920's and 1930's a variety of sympathectomy techniques for hypertension were devised by Adson, Peet, Smithwick, and Grimson. These brilliant procedures have been largely

replaced by *Rauwolfia*. Likewise, perivascular stripping and lumbar sympathectomy are today little used for postphlebitic syndrome.

Even though Linton has reported aggravation by sympathectomy with the development of painful foot ulcerations, "post-thrombotic post-sympathectomy syndrome" (1953), there are indications for this procedure. Sympathetic overactivity is suggested by pain, coldness, and excessive perspiration with persistent fungus infections. In these patients or those with recurrent exacerbations of acute thrombophlebitis, prolonged sympathetic blocks should be tried. Either a long-acting agent can be used or repeated injections of procaine can be made through a fine plastic tubing. Where there is marked improvement and recurrence of disability on discontinuance, sympathectomy should be considered. These procedures should be used in conjunction with repeated femoral artery vasodilator injections, autonomic blocking and sympatholytic agents, and other measures previously described.

Deep Vein Ligations. Theoretically, incompetence and hypertension of the deep veins lend support to the enthusiastic reports on ligation of the popliteal (Bauer, 1938) and of the superficial femoral veins (Buxton, 1945; Linton, 1947). It is generally felt that these procedures are of limited value.

Eradication of Superficial Varices. There is an increasing opinion that superficial varices should be removed, even when associated with or secondary to deep vein incompetence (Linton, 1938). Sclerotherapy may promote ulcer healing without vein surgery, but in most instances should be reserved for residual venules after surgery and for spider bursts. Not more than 1.0 cc. dilute solution should be injected at any one site.

Ambulatory and Support Therapy. The usual procedure of keeping the patient in bed and off work for months to years is not satisfactory. Even though there may be eventual healing of associated ulcers, the patient is usually harmed by weight increase, loss of muscle and tissue tone, excessive fibrosis, and impairment of peripheral circulation.

While only a few can be "cured," with adequate ambulatory therapy more than 90 per cent can be improved and the majority restored to almost their previous work capacity. Only a small percentage of these patients or those with persistent ulceration and massive edema require radical surgery.

VENOUS ULCERS

> Ulceration is not a direct consequence of varicosity, but of other conditions of the venous system with which varicosity is not infrequently a complication, but without which neither one of the allied skin affections (induration and bronzing) is met with, conditions which involve obstruction of the trunk veins, deep and superficial, either from impediments on the venous side, or incompetency on the arterial, or from both causes combined.
>
> —*Gay*, 1868

Many of the early writers, even the great Avicenna, felt that ulcers were caused by

escaping humors and should not be treated. Fallopia, in 1550, wrote of varices carrying feculent humors that caused ulceration. In the eighteenth century LeDran and Heister considered the ulcer as a drain for bad humors. Sharp wrote (1758) that "in old people the cure is often dangerous." In 1801 Hume wrote: "If a patient of a gouty habit has an ulcer on the leg . . . any attempt to heal the ulcer is improper." Nunn (1852) listed conditions in which "it is dangerous entirely to heal an old sore." In recent years several patients have been encountered who believed that the ulcer could not be healed without damage to the general health.

Related to the humoral theory was the concept of menstrual ulcers. Paré (1579) believed that during pregnancy menstrual blood collected in the legs, became stagnant, and produced ulcerations. In the first half of the nineteenth century Cooper and Critchett wrote of ulcers related to amenorrhea. This theory of blood stagnation in the legs was carried over into the venous stasis concept of modern times. The current hormonal therapy of telangiectids and pregnancy varices can be considered an adaptation of the ancient humoral theory.

Hippocrates wrote of the association of varices with lower leg ulcerations, but this concept was not taken up until after Harvey's publication (1628). In 1676 Richard Wiseman described venous thrombosis, venous dilatations, and the effects on the valves. He was among the first to attribute ulcers directly to a circulatory defect and introduced the term "varicous ulcer." Other popular terms are venous (Gay, 1868), postthrombotic (Homans, 1916), postpartum (White, 1918), gravitational (Wright, 1931), and stasis ulcer.

During the eighteenth century there was emphasis on gravity and hydraulics. In 1758 Sharp wrote: "The indisposition of these sores is in some measure owing to the Gravitation of the Humours downwards." Underwood (1783), Bell (1789), and other writers on leg ulcers made no reference to varices as a cause. Whately (1799) stated that "when the body is erect, the blood and lymph return from the extremities contrary to their gravity in a column of several feet." In that same year Baynton had written that ulceration arises:

> from the unfavourable situation of the parts which are placed at a remote distance in the human machine from the fountain of life and heat, and are obliged to return the venous blood and lymph to the heart under some peculiarly unfavourable and disadvantageous circumstances.

In the nineteenth century there was a revival of the varicose concept. Home noted (1801) that ulcers were more difficult to heal if varices were present. Hodgson (1815) wrote of ulcers "which are generally situated near the ankle, and are remarkably intractable. They appear to depend upon the varicose conditions of the veins, for when the latter is relieved, the ulcers are as readily cured as ulcers in general."

Brodie, Chapman, Cooper, Hunt, Hilton, Scott, Critchett, and others supported this view and established the term "varicose ulcer," which has dominated this field until relatively recently (Homans, Wright, McPheeters).

It was pointed out by Nunn (1852) that severe varices could exist without ulceration. The studies of Davis (1822), Verneuil (1855), and Spender (1868) indicated the role of thrombosis and supported Chapman's suggestion that the term "varicose

ulcer" should be abandoned. Gay (1868), who described arterial ulcers resulting from arteriosclerosis, introduced the term "venous ulcer."

In 1916 Homans established deep vein thrombosis as a frequent cause of chronic leg ulcers; he distinguished simple varicose ulcers superficial to the deep fascia (Boyd, 1952). Reports from many centers have confirmed the high incidence of deep vein thrombosis in chronic venous ulcers: Birger (1940); Nilzen (1945); Bauer (1946), 80 to 90 per cent; Anning (1954), 84.3 per cent. Cockett and Jones refer to the "ankle blow-out syndrome" from incompetence of lower leg perforators.

Venous ulcers may be single or multiple, a few millimeters to several centimeters in diameter. The ulcer surface may be erythematous, hyperemic, and weeping or scaly and granular. The base and margins are usually adherent to the deep tissues. The surrounding tissues are usually pigmented, tender, scarred, and atrophic.

Treatment. Even in the presence of marked varices, other causes of chronic leg ulcers should be considered: arterial, traumatic, infectious, mycotic, gummatous, malignant, and miscellaneous. Along with definitive ulcer treatment there is need for attention to factors contributing to ulcer production and interfering with healing: trauma, infection, obesity, dietary deficiency, systemic conditions.

Prolonged bed rest is unsatisfactory. While there is usually healing after weeks to months of bed rest with elevation and local applications, in most instances this is poor healing. Underlying adherence of the ulcer base and its surroundings, scarring, poor local circulation, and a "weak" covering make the ulcer susceptible to minor trauma. Improvement of arterial and venous circulation produces better results. Varicose veins delay healing and increase likelihood of recurrences. Stripping or multiple excisions of the internal and external saphenous veins are advisable in all instances of large or incompetent superficial veins associated with chronic venous ulcers. During this procedure the saphenous nerve can also be sectioned. Lumbar sympathectomy is reserved for ulcers accompanied by coldness, cyanosis, hyperhidrosis, and other evidence of sympathetic overactivity (Boyd, 1950).

Local Applications. The soothing and healing effects of some local applications have been known since Biblical times. Too often leg ulcers are overtreated and sensitized by a thousand and one ointments, pastes, creams, and lotions. Sulfa and 'caine preparations should be avoided. Even for infections, local antibiotics should be used only for a few days and in powder form (Robinson).

Crude pancreatic enzymes had been used for wound and ulcer débridement by John Hunter. A variety of agents such as maggots, papain, and urea have been tried and discarded as unreliable and irritating. In 1950 good results were reported with derivatives from streptococci cultures, streptokinase and streptodornase. The advantage of local applications of proteolytic enzymes, including trypsin, fiacin, and fibrinolysin (plasmin) merits further study. These have been used by themselves and in combinations with blood cell powder, with hyaluronidase, and with iodothyronine.

There are enthusiastic reports of parenteral trypsin in acute thrombophlebitis and a variety of other conditions. The anti-inflammatory and thrombolytic effect has been attributed to restoration of required rate of proteolytic enzyme-protein substrate interaction and to elevation of serum antiproteolytic activity (Grob, 1943).

These mechanisms and indirect inhibition of polypeptide production are difficult to demonstrate.

Itching is often a prominent symptom in nervous disabilities and repeated scratching aggravates the condition. In most instances the skin has been sensitized by a variety of local applications, especially antibiotics, sulfa, and 'caine compounds. Oral antihistamines, warm sitz baths in baking soda or oatmeal, baby oil for dry skin, and liberal use of bland dusting powders are suggested. Diets and measures to improve skin tone should be routine in all peripheral vascular cases. For disabling itching, various combinations of analgesics, oral, parenteral, and local corticosteroids and antihistamines, and ataraxics can be tried.

Ambulation with Compression. In Anning's book there are descriptions of Celsus' linen roller bandage (c. A.D. 25), leather stocking (Wiseman, 1676), flannel roller (Underwood, 1783), and other supporting devices used through the ages. Medicated bandages such as de Chauliac's lead paste (1363) are still used as "diachylon" bandages and in combinations of zinc oxide–glycerin-gelatin as Unna's boot, "viscopaste," and various proprietary preparations incorporated in bandages and applied after painting the area with gentian violet or some similar dye. The elastic plaster bandage, reintroduced by Dickson Wright in 1930, is currently popular as Elastoplast. India rubber bandages (Martin, 1878) provide good support but are unattractive and must be worn with some protection against the skin. There is need for better elastic stockings; those cosmetically attractive are not heavy enough to provide adequate support.

The ulcer or the healed area must be protected and compressed and prevented from becoming hard and dry. Wearing a foam rubber sponge under an elastic support (McPheeters, 1938) and leg elevation for five minutes of every two hours for local massage and exercises should be routine. Repeated hydromassage, contrast sprays, manipulations, and other measures for improving peripheral circulation and general health are essential. Only after adequate trial of these procedures should one consider u'cer surgery. The surgery should be extensive with excision of the ulcer base and its feeder vein, followed by split thickness grafts.

LYMPHEDEMA

> It is not yet clear whether the success which undoubtedly follows this extensive procedure (radical excision) is due to total extirpation of the lymphatic bearing tissue, or whether the skin acts like an inelastic stocking to prevent accumulation of edema fluid.
>
> —*McIndoe*, 1952

Originally the term "elephantiasis" was applied to extremity enlargements of elephantine proportions. Lymphedema is the preferred term, even though some undetected deep thrombophlebitis may be contributory. The development of chronic lymphedema is related in part to the arrangement of the lymph vessels into superficial and deep systems with connections only through the popliteal and inguinal lymph nodes. With destruction of the lymph valves or occlusion by infection, due to lack of collaterals, there is an interstitial protein-rich exudation providing a culture

medium for repeated infections and stimulating fibrosis or fibroedema (Martorell, 1951).

Treatment. For mild cases compression-ambulation, repeated elevation, and conservative measures for improving peripheral circulation are adequate (Boyd, Avid, 1950). More severe edema calls for diuretics, anticoagulants, and sympathetic blocks. The marked cases with disability and repeated infections require surgery (de Takats, 1950). Deep vein ligations and sympathectomy are of no benefit in relieving venous and lymphatic obstruction and reversing tissue fibrosis.

Attempts to create drainage paths have been unsuccessful: silk threads (Handly, 1908); fascial strips to the deep tissue and marrow (Lanz, 1911; Kondoleon, 1912); rubber tubes (Walther, 1919); skin (Gillies, 1935; McIndoe, 1935). Improvement in postmastectomy edema of the upper extremity after implantation of fine plastic tubes may also be applicable to lower extremity edema.

Wide excision of deep tissues for filariasis (Charles, 1912) and the Kondoleon procedure were applied by Sistrunk (1918), Auchincloss (1930), and Ghormely (1935). Current techniques are modifications of that presented by Homans in 1936. Watson turns back fat-free skin flaps and, after excision of all subcutaneous tissue and deep fascia, resutures the flaps onto the muscle. Macey (1940) places thick-split grafts under the flaps. Poth, Pratt (1955), and Janes excise all the involved tissues, except a narrow strip covering the tibia anteriorly, and then place free thick-split grafts. World War II experiences at centers such as Valley Forge General Hospital have shown that such grafts can survive even when placed directly over muscle, tendon sheaths, and periosteum. It is hoped that means will be devised to permit the use of heterologous grafts in these and other patients requiring large amounts of skin. All lymphedema patients should be forewarned that surgery will not provide a "complete" cure, that there will be considerable scarring, and that it will still be necessary to wear elastic support.

Submalleolar "fat pads" constitute a cosmetic problem for many women. Excision is followed by recurrence, often with painful scarring. Weight reduction, improved diet, "sensible shoes," correction of foot imbalance, local massages, exercises, and other measures for improving peripheral circulation are essential. With adherence to these procedures, local injections of hyaluronidase-hydrocortone are usually of some benefit.

SUMMARY

1. Some venous disorders aggravated by, aggravating to, or associated with foot problems have been presented.

2. The essentials of venous and capillary circulation have been outlined.

3. In all venous disorders it is essential to institute measures to improve general health and peripheral circulation.

4. The preferred treatment for varicose veins is stripping under local anesthesia with follow-up sclerotherapy.

5. Recovery from acute superficial thrombophlebitis can often be facilitated by local phlebectomy.

6. Complications in acute thrombophlebitis may be prevented by ambulation with elastic support along with prolonged sympathetic blocks and anticoagulants.

7. Postthrombophlebitic syndrome and venous ulcers can usually be controlled by ambulation with elastic support and foot care.

8. High amputations in thromb:angiitis can usually be prevented by stopping smoking, foot care, and lumbar sympathectomy.

9. Persistent ulceration and marked edema require extensive excision and skin grafting.

10. Early treatment of causalgia by blocks or sympathectomy and early use of the extremity may prevent serious disability.

11. Good venous return and foot health are essential for physical fitness.

Fifth Annual Symposium on Antibiotics

We are pleased to announce that the Fifth Annual Symposium on Antibiotics, sponsored by the Food and Drug Administration, Division of Antibiotics, U. S. Department of Health, Education, and Welfare, with the journals, ANTIBIOTICS & CHEMOTHERAPY and ANTIBIOTIC MEDICINE & CLINICAL THERAPY, will be held on October 2, 3, and 4, 1957, at the Willard Hotel in Washington, D. C.

Submitted manuscripts must contain new, previously unpublished material. They must be typewritten, double spaced, on one side of 8½ by 11 inch paper. No more than six illustrations should accompany each manuscript. These glossy prints should be no larger than 8½ by 11 inches so that they can be clearly reproduced with a one third reduction. Bibliographies should conform to the style of the *Quarterly Cumulative Index Medicus*, published by the American Medical Association. Generic names of drugs should be used throughout the manuscript, except that the first time the drug is mentioned the trade name may be referred to in a footnote.

The original manuscript and one copy must be submitted by September 2, 1957. Five copies of an abstract of no more than 200 words must be submitted no later than August 19, 1957. Please submit manuscripts to:

Dr. Henry Welch, Director
Division of Antibiotics
Food and Drug Administration
U. S. Department of Health, Education, and Welfare
Washington 25, D. C.

Foot Problems: Metabolic Factors

William L. Allen, M.D.

LOS ANGELES, CALIF.

"Look at my child's feet, Doctor, there's something wrong with them." This is a common complaint received from parents and by all of those concerned with child care. "My feet hurt all the time" is another expression often heard. These and other similar complaints on thorough investigation may be found to be the result of metabolic disturbances or disease. Metabolism, defined, is simply "tissue change." This applies to any tissue in any part of the body including the feet. Metabolism further means the sum of all the physical and chemical processes that produce and maintain living organized substance. This includes the transportation of energy required for these changes. Metabolic factors, then, is a term that has a tremendous scope. It includes any process or thing that affects changes in the physiology and physical processes in the body. When we limit our thinking to physiologic changes that affect the feet, we limit our scope of investigation somewhat, but we still have so very much to consider that only scant attention may be given to each factor in a brief presentation such as this.

Foot and leg symptoms, such as muscle spasm, cramps, pain, numbness, tingling, itching, burning, coldness, aching, throbbing, discoloration, breaking veins, swelling, recurrent infections, rashes, paralysis, flatfeet, and pronated ankles, may be the presenting symptoms or later manifestations of a host of metabolic disturbances. A partial list of such metabolic diseases in some way involving foot and leg symptoms would include the following.

Diabetes may present recurrent or persistent infections, thrombosis, or gangrene of the toes, and may be associated with arteriosclerosis with narrowing of the vessels, thereby impairing circulation and producing pain, tingling, or intermittent cramping. Treatment involves adequate diabetic control with diet, insulin, vitamins, and possibly the use of lipotropic substances. In addition, local foot care is mandatory to prevent serious complications. Proper trimming of the toenails to avoid downward projections that will break the skin and promote infections, keeping the feet clean and dry to avoid mycotic infection, and properly fitted shoes that do not cramp the feet are essential factors of correct foot care for diabetic persons.

Arthritides of various types including gout may produce pain, joint enlargement, and sometimes crippling deformities of the feet. These diseases produce symptoms that range from mild to severe. Treatment of the specific type of arthritis must be carried out, and when necessary, special shoes, supports, and/or padding must be provided to give the maximum amount of foot comfort.

Peripheral nerve disorders may produce foot symptoms. Pernicious anemia with tingling, numbness, muscle spasms, and, in advanced cases, anesthesia of the feet is sometimes found. Shooting nerve pains of peripheral neuritis may be due to nutritional deficiency such as produced in alcoholism, pellagra, or beriberi. Toxic metabolic disorders of heavy metals and hydrocarbons and acute porphyria may also produce peripheral neuritis with foot pains. Diagnosis and treatment of these con-

ditions are sometimes quite difficult and require detailed special medical attention.

Vascular disorders, such as thromboangiitis obliterans, Raynaud's disease, and Buergers disease, may produce pain, coldness, numbness, or cramping of the feet and legs. Chronic hyperparathyroidism may produce muscle spasms involving the feet as a presenting symptom. Amyloidosis, glycogen storage disease, and beriberi are examples of metabolic conditions that will produce heart failure with decompensation that may be evident in the feet and legs by the swelling of pitting edema. Abnormal lipid metabolism may be responsible for arteriosclerosis that can cause intermittent leg cramps, localized pain, or gangrene from thrombosis, or numbing and tingling of the feet. Less well known disturbances of metabolism, such as ochronosis, alkaptonuria, calcinosis, scleroderma, lupus erythematosus, may produce foot pains, leg aches, skin ulcerations, or rashes. Such vascular disorders and metabolic diseases are difficult diagnostic problems, and the treatment of each requires careful and specific management to relieve the many symptoms produced, including the foot symptoms.

For this presentation, somewhat more detailed attention will be given to several metabolic disturbances that are really rather common and often produce leg symptoms.

The common symptom of coldness of the feet (and hands) is often due to low blood iodine content. The exact chemistry of iodine in the body is not totally known. Its function in relation to thyroid is evident and measurable to some degree by various tests.[1] The exact mechanism of iodine administration to relieve the cold feeling in extremities is not immediately apparent. Vasodilatation is one possible answer, and general increased metabolism produced by iodine is another possible answer. The latter is less likely. Clinically and empirically, iodine administration in proper dosage will relieve this cold feeling in the hands and feet and may be administered for this purpose provided there are no contraindications to the administration of iodine. For administering iodine, a compound such as Calcidin,* 2½ grains once or twice daily, is effective.

Hypothyroidism frequently affects the feet. Often a child is presented for examination because of flatfeet or a "mushed foot." On further investigation there may be found fat pads on the dorsum of the feet (and hands) or feet with short toes (and fingers). There will be a positive Helbing's sign (a pronation curving of the Achilles tendon as seen from the posterior). Further investigation of the child may reveal some or all of the following: batwing scapulae, protruding abdomen, stringy musculature, rigid, easily broken nails, crowded, soft, easily decaying teeth, slow pulse, and infantile external genitals.[4] Inquiry into the history will usually elicit the fact that the child is irritable, unable to play at one activity for any length of time, has poor concentration, is restless at night, often grinds his teeth, and may have enuresis. The child frequently bites the nails and the horny rough cuticle that is almost always present. The teacher comments to the parents that the child, although seemingly intelligent, is restless and will not continue with any activity except for a very short time. Classically, hypothyroid individuals are groggy in the morning and require

* The trade name of Abbott Laboratories for an iodine combination is Calcidin.

several minutes to "get awake." The children may have to be called several times to get up and adults "must have their morning coffee" to start the day. After-dinner naps appeal to them and one o'clock lectures are quite insufferable. Many think that the hypothyroid child is always obese. However, a greater percentage are actually underweight. Billig[2] states, "If we think of overweight as the typical finding in hypothyroidism in children, we are going to overlook most of these cases." This is in agreement with Harstock,[5] who states, "Insipient hypothyroidism is by far the most prevalent and most difficult to recognize of all the types. If one keeps a mental picture of myxedema before one as a guide to the diagnosis of hypothyroidism one will entirely overlook 75 per cent of the patients who have very mild symptoms of great variation, but who require specific thyroid substance for relief of these symptoms."

Roentgenogram will reveal that the epiphysial appearance time of the tarsal and other bones is delayed. Such appearance time for normal can be ascertained from standard charts such as that of Todd and Sanford. This correlation of thyroid function with delayed osseous development has long been noted.[3] Blood cholesterol elevation is almost always present, and when found with delayed osseous development and some of the symptoms listed, thyroid substance should be administered.[4] When thyroid therapy is instituted, it is essential also to give calcium, which in growing children may be removed from the blood stream rapidly to be deposited in the bones that are delayed in development. This element, calcium, which forms insoluble salts and soaps in the intestine, must be given in a manner that produces maximum conditions for absorption. Calcium lactate, the most soluble form of calcium, when given in a more acid stomach and media will result in the maximum absorption. Calcium lactate given in citrus juice 30 minutes before breakfast is a very effective means of administration. When a more palatable preparation is necessary, sirup of calcium gluconogalactogluconate, on an empty stomach, has been found effective and well tolerated by the patient in doses of 1 to 2 teaspoons. (In connection with calcium therapy it must be mentioned that muscle cramps in the legs and feet appearing without other symptoms are usually relieved by calcium therapy, despite the fact that blood calcium studies are normal and other reasons for muscle cramping have not been found.)

Hypoadrenia is another metabolic disturbance that may be evidenced by foot symptoms similar to and sometimes confused with those found in the hypothyroid person. The adrenal cortex produces some 28 or more steroid compounds, of which many are physiologically active on distant organs and tissues. These hormones exert many metabolic influences to include carbohydrate, protein, fat, and mineral. Since the days of Addison in 1855, it has been known that the adrenal cortex hormones are essential for life and that a chronic or acute insufficiency of these hormones leads to general debilitation and death. In 1926 Hisaw pointed out a relation of the steroids to ligamentous relaxation.[6] Recently, more specific hormones of the adrenal cortex have been isolated and their specific functions are better understood. As an example, the effect of adrenal hormones and ACTH, the factor from the pituitary that stimulates liberation of adrenal hormones, is well known in arthritis and many other collagen disease syndromes. A clinical syndrome of chronic, mild adrenal cortical

hormone insufficiency has been recognized.[7] This is characterized by pronated ankles, mushy muscular tone, slumped posture, increased posterior pharyngeal lymphoid tissue, flushing of the ears with some waste product deposits similar to tophi on the brim of the ears, soft, easily broken nails, and increased perspiration of the palms and axillae. These patients perspire so freely when under nervous tension that during examination they may have small puddles of perspiration on the table beside them. This latter phenomenon of vasomotor instability is also reflected by a labile blood pressure especially labile on a sigh type of respiration. Stiffness and tightness in neck and back ligaments are often found. The person with hypoadrenia will usually tire quite easily. This is especially noted in children because they become emotionally unstable when fatigued. In children with hypoadrenia, temper tantrums are prominent and the personality is quite irritable. These children often dream a lot at night and awake in the morning frequently tired despite a full night of sleep. Corrective exercises to hold up their pronated ankles and dorsal round backs of the spine are ineffective because the muscles are just too tired to do the work effectively for any length of time. Correction of these tired pronated ankles is best accomplished by systemic therapy employing adrenal cortical extracts in addition to corrective exercises. Injections of adrenal cortex extracts, 2 cc. intramuscularly two to three times weekly, followed later by oral administration of Corticaps, one tablet three times daily, has been found quite effective.

Closely associated with the low adrenal cortical function is the disturbance of uric acid metabolism. This condition in its acute form is classically known as gout and is notorious in attacking the feet, particularly the great toe at the metacarpophalangeal joint. The exact mechanism of adrenal hormone function in control of and treatment of gout, acute and chronic, is only partially understood. The effect of the adrenal steroids on acute gout is quite dramatic and has been well demonstrated by William Wolfson.[11] The old stand-by drug, colchicine, long used in the treatment of acute gout, also has an obscure but rather effective function in chronic disturbance of uric acid metabolism. It is particularly effective in conjunction with the adrenal steroids. This drug, colchicine, is basically steroid in chemical construction, and it could be postulated to be an intermediary compound or precursor in steroid metabolism as it affects collagenous tissues. Individuals with foot ache and other joint pains who fit the clinical picture of cortical hypoadrenia will respond most dramatically to a maintenance dose of colchicine after symptoms have been controlled with adrenal cortical steroids or ACTH. These same individuals almost always have a tightening of fascial and ligamentous tissue as denoted by decreased range of joint motion, especially of the spine. Such fascial tightening can produce peripheral nerve compression irritation so that peripheral foot pains may develop.[7] Active and passive stretching exercises[7, 8] used concomitantly with steroids and colchicine[14–21] have given excellent results. After cessation of the maintenance dose of colchicine these patients may have return of the aching, stiff joints in weeks to several months. The foot pain will usually return first because of the stress and trauma placed on the feet by daily use. Resumption of colchicine therapy will provide relief. Maintenance dose of colchicine is attained by carefully increasing dosage to a point just short of causing gastrointestinal symptoms, such as cramping,

TABLE I

High Protein—Low Carbohydrate Diet

Select from the Following Foods

VEGETABLES

Avocados
Asparagus
Artichokes
Beans, string
Beet greens
Beets
Broccoli
Brussels sprouts
Cabbage
Carrot
Cauliflower
Celery
Cucumber
Eggplant
Endive
Kale (collard)
Leeks
Lettuce
Mushrooms
Okra
Olives
Onions
Radish
Rhubarb, no sugar
Rutabagas
Sauerkraut
Spinach
Swiss chard
Tomatoes
Tomato juice
Turnips
Watercress

FRUITS

Grapefruit or juice, no sugar
Lemons
Muskmelon, cantaloupe, or honeydew
Papaya
Strawberries
Watermelon

DAIRY PRODUCTS

Butter
Buttermilk
Cheeses
Cottage cheese
Milk: whole or skim
Cream: average or thick

MEATS

Bacon
Beef, roast
Beef, steak
Beef
Chicken
Fowl
Ham
Heart
Lamb
Liver
Lean meat
Pork chops
Sweetbreads
Turkey
Veal cutlet
Veal roast

FISH

Bass
Codfish
Halibut, fresh
Herring
Oysters, raw
Salmon, canned
Sardines, canned
Trout: brook or lake
Tuna

NUT MEATS

Brazil
Butternuts

MISCELLANEOUS FOODS

Artificially sweetened soft drinks
Broth
Cod liver oil
Cooking fat
Custard, without sugar
Coffee and tea
Eggs
Gelatin, no sugar
Ham
Lard
Mineral or salad oil
Nutti brown flour, bread, or crackers
Saccharin or Sucaryl tablets or liquid as artificial sweetening
Soy crackers

Avoid the Following Foods

VEGETABLES

Artichokes, Jerusalem
Beans, kidney
Beans, lima
Chili sauce
Corn
Parsnips
Peas, green
Potatoes
Potato chips
Succotash

FRUITS

Apples
Apricots
Bananas
Blackberries
Blueberries
Cherries
Cranberries
Currants
Gooseberries
Grapes or grape juice
Huckleberries
Oranges or orange juice
Peaches
Pears
Pineapples
Plums
Prunes
Raspberries

DAIRY PRODUCTS

Malted milk

CEREALS, BREAKFAST FOODS

Cream of wheat
Cornflakes
Oats
Puffed rice
Rice
Shredded wheat biscuits

NUT MEATS

Almonds
Chestnuts
Filberts
Hickory
Peanuts
Peanut butter
Pecans
Pistachios
Walnuts: black English

MISCELLANEOUS FOODS

Alcoholic beverages
Carbonated drinks
Chewing gum
Chocolate
Cocoa
Ginger ale
Honey
Ice cream
Macaroni
Spaghetti
Sugar, granulated

BREAD, CAKES, PASTRIES

Bread
Cake
Cookies
Crackers
Pie
Pudding

nausea, increased bowel movements. In chronic disturbance of uric acid metabolism, roentgenographic and blood uric acid studies often will not be diagnostic as they would be in the acute gout syndrome. However, small punched-out areas of bone sometimes appear on roentgenograms in the subchondral area of the joints, especially noticeable in the great toe and sacroiliac joints. This may represent early uric acid deposits.

Another metabolic factor closely associated with foot pain and often with hormonal disturbances is obesity. Obesity as such can cause foot distress by wear and tear on the ankle, the tarsal, the metatarsal, and the pedal phalangeal joints due to the excess weight being constantly transported. Obesity may be caused by mechanisms other than excessive calorie intake. Such syndromes as pituitary, adrenal, and thyroid obesity are well known but not too frequently seen. More frequently seen as obese patients are those with a syndrome called "functional hyperinsulinism."[9] These individuals with obesity and/or hyperinsulinism, in addition to other symptoms, have a lower threshold of pain so that stimuli that would ordinarily be unnoticed become irritating or painful to them.[10] Joints in the obese, then, may be painful due to the excess weight stimulating the joints and muscles, which are more sensitive because of the lower threshold of pain. This obesity, whether due to typical hyperinsulinism or just plain overeating, may be best controlled by a high protein–low carbohydrate diet. Reduction by such dietary control will help relieve the foot and leg symptoms by the mechanisms just listed. A diet such as that listed in table I has been found most helpful when strictly followed. Patients who follow this dietary program will gradually lose fat weight and their appetite for carbohydrates. Modification of the diet may be allowed after several weeks or months without the patient's gaining weight. The total caloric intake does not seem to be of so much importance as the fact that carbohydrates are practically eliminated from the diet. The physiologic mechanisms for the effectiveness of such a dietary regimen have been discussed by Pennington.[12, 13]

SUMMARY

In summary, many metabolic diseases may present symptoms relative to the feet and legs. Low thyroid iodine, chronic mild hypothyroidism, chronic mild hypoadrenia, chronic urate metabolic disturbance, and obesity with and without the association of functional hyperinsulinism are common but less recognized specific metabolic clinical syndromes with foot and leg symptomatology. A brief discussion of the symptomatology and therapy of these syndromes is presented.

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SYMPOSIUM ON MEDICINE AND WRITING

The Symposium on Medicine and Writing that appeared in the November 1956 issue of International Record of Medicine has been published recently as a Monograph. The articles included in this Monograph are: "The Editing of a Modern Medical Textbook" by Russell L. Cecil; "Plain Talk and Clear Writing" by Morris Fishbein; "The Principles of Bibliographic Citation" by John F. Fulton; "The Art of Communication" by Joseph Garland; "On Writing a History of Medicine" by Douglas Guthrie; and "Minerva and Aesculapius: The Physician as Writer" by Félix Martí-Ibáñez.

This 72 page Monograph is sold for $3.00. As the fourth in the series of MD International Symposia, this book is the companion piece of *Medical Writing*, which was published in May 1956.

To obtain this monograph, write to MD Publications, Inc., 30 East 60th Street, New York 22, N. Y.

Significance of Neuronal Developmental and Conditioned Patterns in Control of Function of the Foot

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THE BILLIG CLINIC

LOS ANGELES, CALIF.

DEVELOPMENTAL PATTERNS

The importance of the sequential development of patterns of function of the muscles in maturation of the individual has been clearly shown by Dr. Arnold Gesell[1] and his co-workers at the Yale School of Child Development.

Flexion and extension movements are the two most fundamental components. Which component predominates depends on the "developmental age" stage of growth of the individual. By analyzing posture attitudes and posture movements this can be determined. It is important to note not only whether flexion or extension movements predominate, but also whether there is a balanced shift of power back and forth between flexion and extension with smooth coordination.

Flexion movements precede extension in sequence of development and predominate exclusively in the uterine stage.

In the fully matured patterns of neuromuscular movement, neither flexion nor extension predominate exclusively. Both are in close association, well balanced, well coordinated, smoothly executed. The ultimate goal, therefore, is to achieve smooth balance between both components for fully developed mature movement.

Certain pathologic states such as spastic conditions are examples of the predominance of one component over the other, e.g., hip flexion over extension, knee flexion over extension, hip adduction over abduction, foot plantar flexion over dorsiflexion. To call into play the extension patterns of foot function in pathologic conditions is basically similar to the problems of training (neuromuscular education or re-education) in nonpathologic conditions.

Another factor, dealing with developmental patterns, concerns the direction of development. The cephalocaudal direction is described as the direction in the total sweep of development. The head is lifted in the first week of life. The foot motions are developed last in the sequence, being both caudal and distal.

What are the implications of lingering flexion predominance in delayed development? Since the patterns of flexion developmentally precede extension, there is a tendency to have stronger action on the flexion side with equinus dominance. This is also, from a structural point of view, an inheritance from quadripedal ancestors. Whether our flexion predominance tendencies stem from this source or our flexion precedence patterns, we nevertheless face a constant need in foot training to induce relaxation of the heel cord muscles, balanced with dorsiflexion action of the ankle. This need is ever-present in a body mechanics program for the growing child as well as for the adult.

Furthermore, since the neuromuscular pattern of foot function develops last embryologically, the indication for mature balanced coordination of flexion and extension may be a later development rather than an early phenomenon. We do not expect the delicate synchronization of foot movement in the preschool child, and he may not achieve it until a relatively late stage of growth. An average 2 year old has a flat arch since the functioning factor of the posterior tibial does not come into effect until approximately 4 years of age and the perfect synchronization of that muscle with the anterior tibial comes at a still later stage.

Hence, tap dancing, for example, would not be a recommended activity for the average first grade student. However, at the fifth grade level, if the child still cannot "pick up" his feet with smooth coordination, we may conclude that there is delay in the mature functioning of the feet. Foot work in hops, leaps, marching, and strong rhythms are indicated in a training program.

As advocated by the Billig Clinic, the use of rhythms as a means of developing mature patterning coordination of muscular movement is strongly recommended. The work of research investigations[2] has shown that proprioceptive centers (skeletal muscles, tendons, and joints stimulating the higher nerve centers and relaying back to the same structures) stimulated through rhythm activities accelerate the response of development of mature patterning and hence balance of flexion-extension movements. It has been shown through rhythm activities that the maturing process can be stepped up considerably and accomplished earlier than would ordinarily occur without rhythm stimulation in a permissive environment that avoids proprioceptive stimulation. Our city environment limits the opportunity for proprioceptive stimulation. We attempt to meet this need in the schools. Hopping, skipping, dancing, marching to rhythm are some of the activities strongly indicated in the early school years to provide the opportunity for proper speed of foot function development.

CONDITIONED PATTERNS OF REFLEXES

By this term, as differentiated from the developmental patterns, is meant environmentally stimulated conditional reflexes of the Pavlovian type. The individual comes into this world equipped with certain nerve pathways that enable him to move in a complex and phenomenal manner. Pavlov showed that these very same pathways are subject to much variation of conditioned response depending on the control of the environment. One example in the body mechanics field is as follows.

An everted foot in the first two years of life gives the child a broader base to operate from in the uncertain years when balance is still in its initial stages. As coordination and control develop, the feet take a less everted position. It is not uncommon to find the school child at the seventh and even the tenth year still using the feet in the extreme everted position as in infancy. Balance and coordinate factors in other parts of the body may have developed. In observing the parents of these children, we find that their standing and walking positions of the feet are also in the extreme everted position. The child has been conditioned through imitation and constant repetition to use his feet in this undesirable position. The mimic of another's "limp" will, if not corrected, become a fixed habit at times.

The use of conditioned reflex learning process in a physical developmental program is efficient, especially when applied early. The task involves controlled environment, repetitive performance, and subject response as fundamental factors that go into the training and retraining program.

The training task becomes truly formidable in the junior and senior high school age groups. Hopes for success are most rewarding when emphasis and focus are placed in early years at the time of development of the pattern stages of growth. Directives and control must fit into the proper age sequence patterns as essential ingredients for the learning of good foot function.

SUMMARY

Education and re-education for foot postural muscle function in the growing child should be done within the limits of the developmental patterns for true effectiveness.

The importance of recognition of and analytic use of conditioned reflex patterns of control of muscle function when applied to physical function learning is pointed out.

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New Oral Anti-Diabetic

Now being tested clinically is a new form of oral anti-diabetic drug not related to the sulfa compounds in current use. It was developed in the research laboratories of the U. S. Vitamin Corporation.

In 90 patients treated at New York Medical College under direction of Dr. Julius Pomeranze, drug was effective in daily divided dosages from 25 to 300 mg. More than 75 per cent of diabetics showed good control of blood sugars without insulin, remainder were controlled with DBI and small insulin doses. Reported Dr. Pomeranze: drug is active in all types of diabetes mellitus.

Similar results are reported from Boston's Joslin Clinic by Drs. Leo Krall and Rafael Camerini-Davalos who also obtained 75–80 per cent of control in 75 patients. Supplies of the drug are at present limited.

Whole subject of oral anti-diabetic drugs in clinical practice was recently thoroughly thrashed out at a Symposium organized in New York City.

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Foot Pains

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Medical textbooks seldom make much reference to foot pains. Yet the simple but painful corn can in industry upset the morale and in children be the forerunner of chronic foot and leg pains. Painful foot conditions associated with cardiovascular,[1, 2] diabetic, brain and spinal cord disorders, herniated intervertebral disc, blood dyscrasias, and other closely related medical problems are considered elsewhere in this symposium. Foot pains may be divided into two categories: those caused by local irritations and those due to an irritation in a higher anatomic level of the body.

Local irritations include common corn (heloma durum), soft corn (heloma molle), ingrown toenail (onychocryptosis), tailor's bunion, hypertrophied condyles of the phalanges and metatarsals, neuromas, neurofibromas, and cysts. Management of these painful foot expressions has been directed to surgical intervention with good results.

In addition to surgery for the local irritation, other methods are employed for the redistribution of weight-bearing areas of the foot in order to relieve pressure points. This is accomplished by the use of padding, wedging, or raises of shoes and/or appliances made from materials such as cork, leather, metal, etc. The main objective is to direct the foot from inversion or eversion, thus adjusting the transmission of the weight of the body through the bony structure. True asymmetrical leg length should be compensated for by appropriate lifts (inner or outer shoe height) to prevent development of secondary short leg scoliosis.

LOCAL IRRITATIONS

The correction of the following local irritations is achieved through surgical intervention.

Heloma Durum. Heloma durum, or hard corn of the fifth toe, is usually present for months or years before acute symptoms of pain occur. There is a stinging and burning pain of the fifth toe. This condition occurs in the foot in which the lesser toes do not conform to the pattern of the average foot and average shoe last. Shoes are made for the average type foot and do not have room for the distally projected fourth and fifth toes. The confinement of the foot in the stylish but cramped shoe causes a buckling or hammertoe effect of the lateral toes.

Continued wearing of shoes of this type causes permanent changes to bone and soft tissue structures of the toes. There is hypertrophy of the heads of the proximal and mid-phalanges. There is hypertrophy and marked hard callosity over the affected bones. In some instances, there are contractures of the extensor tendons.

TREATMENT. A one inch longitudinal incision on the lateral border is carried from the base of the proximal phalanx through the corn or callous formation to the distal portion of the phalanx, and the extensor tendon is exposed and reflected to one side. The capsules of the proximal and the distal interphalangeal joints are

opened and freed by sharp dissection. A closed curved mosquito hemostat is forced around the head of the proximal phalanx to the plantar aspect, and with a slight prying motion the head is brought into view. Using a very small bone forceps, one fourth of the distal portion of the proximal phalanx is removed together with the hypertrophied portion of the lateral border of the entire length of the middle phalanx.[3] If there is an extremely long toe, a middle phalanx phalangectomy is performed, and the lateral condyles of the heads of the proximal and base of the distal phalanges are reduced to normal size. The use of deep sutures is not advised because of constriction of the deep soft tissue preventing the mid-phalanx from approximating with the proximal, and the end result would be an "hourglass"-shaped toe. Closure is by interrupted 000 dermal sutures.

The toe is splinted by one eighth inch of felt. One strip of felt, one quarter inch by one half inch, is placed between the fourth and fifth toes. A one quarter inch square is placed on the plantar surface of the distal end of the toe. A one quarter inch by one half inch felt is placed over the dorsum of the toe. The wound is dressed with sterile gauze and an Ace bandage is used to hold the toe in proper position. Sutures are removed in 10 days. The felt splints are kept in position for two months. The patient can return to work the third postoperative day. The residual scar disappears very rapidly and by the end of six months no trace is evident. This procedure produces extremely satisfactory results and makes it again possible for the patient to wear shoes of choice.

Heloma Molle. Heloma molle or soft corn usually lies in the web between the fourth and fifth toes. The condition is not only very painful but is subject to recurrent infections. The cause is compression of soft tissue between the underlying lateral bony projection of the head of the fourth metatarsal and lateral condyle of the proximal phalanx of the fourth and the adjacent fifth metatarsal head and base of the fifth proximal phalanx. The compression results in inadequate blood supply to the involved area.

Treatment. Surgical excision is made of the underlying bony projections causing the compression of soft tissue. A longitudinal incision one and one quarter inch in length is made lateral to the extensor tendon over the fourth metatarsal phalangeal articulation. The capsule is opened and reflected laterally from the head of the metatarsal and the condyle of the proximal phalanx. With a sharp osteotome three sixteenths of an inch in width, the lateral projections of the head of the metatarsal and of the condyle of the proximal phalanx are removed flush with their shafts. The capsule is then closed with 00 chromic, the subcutaneous with 00 chromic, and the skin with 000 dermal interrupted sutures. A sterile dressing is applied and wrapped with Ace bandage. Ambulation is permitted the first postoperative day and the patient is permitted to return to work in two weeks.

Plantar Lesions. One of the most painful foot problems is the lesion that appears on the plantar surface of the forefoot, usually under one or more heads of the metatarsals. The diagnosis of the local lesion is often verruca, callosity, or keratoma.[4] Various forms of palliative local therapy do not have much value. The etiology is usually a hypertrophy of the fibular plantar condyle of the heads of one or more of the four lesser metatarsals or hypertrophy of the tibial hallux or fibular hallux

sesamoids. In many instances, the hypertrophied sesamoid is bipartite or tripartite and the treatment is surgical excision. Compere[5] has indicated that developmental variations of the cuneiform-metatarsal articulations cause a greater plantar angulation of one or more of the metatarsal shafts, and that the heads of the metatarsals are traumatized and hypertrophied because of the concomitant unequal weight distribution.

TREATMENT. Dorsal longitudinal incision is made lateral to the extensor tendon of the metatarsal-phalangeal joint. The capsule is opened and freed by sharp dissection. The joint is disarticulated by pressing the phalanx plantarward, bringing the head of the metatarsal into view. A thin jawed-bone forceps is placed longitudinally from distal to proximal on the plantar aspect of the head and shaft of the metatarsal, and the plantar condyle is removed flush with the shaft.[6]

Billig's[7] approach is from the plantar surface. A longitudinal incision is made lateral and proximal to the metatarsal-phalangeal articulation. The flexor tendon is reflected to the side, and with a sharp osteotome the offending plantar condyle is removed.

An anterior three sixteenths inch metatarsal bar is fixed to the shoe until residual swelling has gone. The disability is for only a few days.

Tailor's Bunion. Tailor's bunion is a painful callosity over the abnormal projection of the lateral border of the fifth metatarsal head. There is hypertrophy of the lateral border of the fifth metatarsal head and of the lateral condyle of the proximal phalanx of the fifth toe. The friction pressure of fitted shoes produces this condition over the bony prominence.

TREATMENT. An elliptical incision is made dorsal to the head of the fifth metatarsal-phalangeal joint. The capsule is reflected from the joint by sharp dissection. A sharp osteotome is used to remove the hypertrophied portion of the lateral head of the proximal phalanx flush with the shafts of the bones. Closure of the capsule is made with 00 chromic and 000 dermal sutures for skin.

Onychocryptosis. Patients with ingrown toenails usually have a bulbous distal phalanx. The nail plate itself may be involuted on one or both sides. Concomitantly, the medial and lateral soft tissue borders may express compensatory hypertrophy. The condition is usually caused by wearing short shoes and socks and by improper cutting of toenails. It is important to keep in mind that woolen hosiery has a tendency to shrink after washing. The toenails should be cut straight across to allow the free border of the nail to extend slightly beyond the soft tissue nail folds. These factors are extremely important in diabetic and trophic conditions.

TREATMENT. The treatment is surgical. A sharp osteotome one eighth inch wide is forced from the free edge through the nail proximally along the striation of the nail to the distal edge of the matrix on the side of the ingrown nail. The offending border may be from a minimal up to one quarter of an inch of the nail plate. A no. 15 blade is used to make a longitudinal incision one half inch proximal to the lanula in line with the "nail split" made by the osteotome. The incision is carried distally deep through the matrix and the prepared split nail plate to the distal portion of the phalanx. The lateral nail plate (ingrown portion) and matrix are carefully resected *in toto*. A wedge of skin together with its underlying tissue is removed

from the distal portion of the incision as far proximalward as to include the hypertrophied border of soft tissue lying along the side of the previous site of the ingrown portion of nail. The freed border is pulled distally as on a bias and the skin edges of the incision are approximated. Two interrupted 000 dermal sutures are used for closure distally. Two 000 dermal sutures are used to close the matrix incision, care being taken that the needle does not injure the intact matrix.

It is strongly recommended that only one border of the nail plate and matrix be removed at one time. If both borders are removed, the resultant swelling may break open one or both incisions. Pressure bandage to reduce bleeding is employed. Sutures are removed in 8 to 10 days. Disability is for one day.

Fungus-Infected Nails. Mycotic disorders of the toenails are for all practical purposes caused by only three species of fungi: (1) *Trichophyton gypseum*, (2) *Trichophyton rubrum*, and (3) *Candida albicans*.

Treatment. There is a multitude of treatments for fungus-infected toenails including dozens of local preparations, roentgen ray, ultraviolet, and many surgical procedures. The results are not too encouraging. It is my impression that Locke's[8] procedure is the most effective. It is as follows.

By means of a steel bur attached to a dental type drill, the nail is thoroughly removed. The nail bed is packed with 60 per cent salicylic acid; the patient is instructed to keep the dressing dry and to return in one week. The tissue affected by the acid is then débrided. The patient is then instructed to scrub the nail bed for one minute daily, using a brush and a detergent soap. The nail bed is dried and one minim of 10 per cent undecylenic acid is placed on the nail bed. The patient must return for reburring of the residual fungi of the nail every month for three to six months. Full cooperation of the patient must be maintained throughout the duration of the treatment.

Verruca Plantaris (Wart). It is apparent, because of the high incidence of verrucae and the multiplicity of methods of treatment, that none of the currently available methods are completely satisfactory.[9] Treatments range from psychotherapy, electrodesiccation, and possibly cautery to roentgen-ray or radium exposure.

Many chiropodists have used with success 80 per cent monochloracetic acid or 60 per cent salicylic acid ointment applied directly to the lesion, while at the same time shielding the surrounding skin and relieving weight-bearing through appropriate protective padding. Four to six applications are given at weekly intervals, after which time the lesion is destroyed. In rare instances, after years of unsuccessful treatment, the growth disappears spontaneously. Usually the lesion is successfully eradicated in a short time by conventional methods. On occasion, however, we are confronted with the resistant verruca, which usually, but not always, is morphologically of the mosaic type.

Steinberg[9] suggests the presence of a metabolic defect causing a vitamin A deficiency in the skin. He further states that the oral or parenteral introduction of vitamin A would require enormous and probably toxic doses to effect a substantial rise in vitamin A in the skin. Therefore, an intradermal injection of vitamin A directly into the lesion is indicated.

Technique. The lesion is anesthetized by injecting procaine subdermally about

one quarter inch from the periphery. The initial dose should not exceed 0.1 cc. of this vitamin A solution and should be injected intradermally into the base of the lesion. Injections are given at weekly intervals. From five to eight injections are necessary with the average resistant lesion. The solution for verrucae contains: vitamin A palmitate, 2.96 Gm.; alpha tocopherol, 0.40 Gm.; sesame oil, 0.60 Gm.; polyoxyethylene sorbitan mono-oleate, 10.0 Gm.; water q.s., 100.0 cc. This approach is being viewed with interest. Reports indicate that the treatment is successful in most cases of resistant verrucae.

Epidermophytosis. The most common dermatologic lesions of the foot are those caused by fungus infections. More than 100 species of fungi are known to be responsible for the various dermatophytoses.[10]

For clinical purposes fungus infections may be divided into classifications of acute, subacute, and chronic.

Treatment. In the acute stage a continuous 10 per cent Burow's solution is indicated. In the subacute, bullae (blisters) should be opened, dried, and painted with 2 per cent tincture of iodine. In the subacute stage when no bullae are present, as well as in the chronic conditions, 10 per cent undecylenic acid solution or ointment is applied to the foot twice daily. An excellent systemic antibiotic effective against fungi is nystatin.

Prophylaxis. The shoes should be fumigated with 5 per cent formaldehyde; however, it should be borne in mind that certain people may be allergic to the formaldehyde. A 5 per cent undecylenic foot powder should be used daily.

Conclusion. For most fungus infections of the foot, 10 per cent undecylenic acid produces good results.

THE FOOT IN INDUSTRY

The care of the foot in industry is surely a major problem involving the worker, the employer, the insurance companies, and work productivity. Actuary reports indicate that 20 per cent of all injuries involve the extremities and are responsible for the loss of more than a billion dollars yearly.

Most workers who are not required to wear safety shoes will wear old, broken-down shoes that have long previously lost all fit and support. In many instances, inadequate foot care leads to backache, fatigue, strain on the cardiovascular system, and inefficiency in general. It is important to have proper weight distribution of the body in relation to the foot. Many times this can be accomplished only by an accommodating foot-balancing appliance, or heel-wedging, with or without Thomas heels, lateral or medial sole-wedging, and an anterior metatarsal bar.

A correctly fitted shoe is one that allows ample toe room, gives adequate support, allows proper flexion and extension of the metatarsal-phalangeal articulations, and fits snugly in the heel. The fit of the heel is particularly important because a friction irritation can cause blisters with the possibility of a severe infection. Stein's[11] remarkable studies indicate that the proper shoe has yet to be designed.

In industry the function of the safety shoe is to prevent injuries. The requirements of a safety shoe are as follows: (1) protection of the entire foot against chemical

and fire burns, (2) protection of the entire foot against crush injuries from adjacent and falling and rolling objects, (3) protection of the entire foot against undue temperature changes, (4) protection of the foot against undue moisture.

Present safety shoes do not meet these requirements. The steel toe box is designed to protect the toes. Unfortunately, in many instances, a heavy falling object may cause the steel toe box to be a crushing vise that holds the crushed toes inside the "safety shoe." Guards, flaps, duckboards, and spats are designed to protect the foot and ankle, but the worker rarely wears them because of their cumbersome effect on walking. A shoe must be designed that will meet the requirements of safety and at the same time be practical for work requirements.

A shoe designed by Shecter seems to meet the above requirements. "An approach and answer to this problem was the creation of a protective foot gear which does not look like a dress shoe, any more than safety goggles look like spectacles. This shoe is made of a one piece plastic laminated mold with tremendous impact and crush resistance. The inside of this protective foot gear is made comfortable by an inner liner consisting of 'Fluid Insoles,' a self moulding shock absorbing material, and a self lining which surrounds the foot. The foot is placed into this protective foot gear by a zipper opening at the rear seam, thus protecting not only the toes and instep, but also the entire ankle."[12]

FOOT PAINS RESULTING FROM IRRITATION OTHER THAN LOCAL

Foot pains resulting from irritations other than local include heel pains, metatarsalgia, spastic hammertoes, chronic sprained ankles, Morton's toe, cramps, and numb first toe syndrome. All methods of treatment, conservative as well as radical, based on the assumption of local irritation as the only causative factor have not offered satisfactory results. A new approach to these foot problems has therefore become necessary.[13, 14]

Heel pains and other peripheral nerve pains of the foot are frequently caused by higher level fibrous tissue (fascial ligamentous) contracture producing nerve pathway compression and irritation. Peripheral nerves from the spine pass through and by fascial ligamentous bands (ligamentum flavum, etc.). If these fascial ligamentous structures are abnormally shortened or broadened, there will be restriction of range of motion, and compression and irritation to the motor and sensory nerve pathways will develop, giving peripheral motor and sensory expression, such as pain, muscular spasms, tingling, and numbness, in their nerve distribution in the feet.[15]

The treatment that has been adopted consists of freeing the peripheral nerves from their fascial ligamentous compression irritation by means of loosening through repetitive accumulative stretching exercises. This loosens the fascial ligamentous structures, which from the ligamentum flavum are continued distally as anterior and posterior lateral femoral fascia, are then inserted into the iliotibial bands,[16] and are attached at the lateral condyle of the tibia.

For example, a patient with "*heel pains*" ("stone bruises") may state that he sustained a heel injury months or years previously and had had intermittent heel pain and tenderness ever since. Roentgen-ray examination of the heels may reveal

the presence of exostosis. Often on the symptomatic foot the exostosis may be relatively small or completely absent, while on the symptom-free foot there may be a large exostosis or calcified thickening of the plantar fascia at its attachment to the heel. Neither surgical excision of the "spur" nor conservative treatment by shoe correction and foot- and heel-shielding has produced satisfactory results. At examination, the patient, standing erect, is instructed to touch the floor with his finger tips without bending the knees. The maximum reach is usually 10 inches from the floor. When forward bending is forced past the restrictive limit, the heel pain is exacerbated. Contractures of fascial ligamentous bands run posteriorly past the pelvis causing compression irritation of the nerve supplying the foot (heel in this case).

Morton's toe is caused chiefly by a higher level fascial ligamentous contracture irritation to peripheral nerves similar in mechanism to that of the heel pains just described. A typical history of Morton's toe is intermittent pain in the region of the third or fourth metatarsal phalangeal articulation, many times so severe that the shoe must be removed and vigorous massage of the foot is necessary.

Objective examination of the foot reveals no pressure point tenderness. Forward bending, with knees kept stiff, is limited to eight inches from the floor.

Contracture of the fascial ligamentous bands, frequently the ligamenta flava, causes impingement to the nerves supplying the feet. When, at times, a neuroma is present in the nerves of the feet, the treatment is surgical excision.

Women frequently complain of a *numb first toe*. A history will usually reveal that the patient has worn high-heeled shoes for a considerable length of time prior to the examination.

Objective examination shows the feet to be normal but there is a lordosis of the lumbar spine region. When the patient tries to touch the floor without knee-bending, flexion of the spine is limited and pain is present in the lumbar back region radiating into the posterior thighs, calves, and big toe.

A typical history of nocturnal *foot cramps* will include the fact that the patient has had to get out of bed several times during the night and walk the floor to get relief.

Objective examination shows that the shoes are well fitted and the feet normal. Forward bending with the knees stiff is limited to within 12 inches from the floor. When forward bending is forced past the restrictive limits of the ligamentous bands, tingling and cramping are felt in the feet.

In examination for complaint of dorsal or plantar *spastic hammertoes*, the patient is placed on his back on a treatment table with legs fully extended. Straight leg-raising will exacerbate the spastic hammertoes at the point where ligamentous restriction is reached. If the straight leg-raising is then stopped for a few seconds, the exacerbation will subside and reappear when the straight leg-raising is again forced to the point of fascial ligamentous restriction. In fact, exacerbation of complaint of chronic heel pains, metatarsalgia, Morton's toe, cramps, tingling, and numb toes can also be noted by this test, thus demonstrating the fascial ligamentous etiologic connection. Forcing the flexion (straight leg-raising, Baer type) past the point of restriction is therapeutic by stretching and elongating the ligamentous bands through which the nerve supply to the affected parts passes. Treatment by means of

loosening the contracted fascial ligamentous bands relieves the specific compression nerve irritation. In addition to the forced passive stretchings, the following specific active stretching exercises are given in order to maintain and also progressively advance the loosening of the shortened constricting ligamentous bands.

The patient is instructed to stand, with knee kept stiff, on the affected leg about 20 inches from and with his back to a table, reaching back and resting the hand of the affected side on the table for balance. The opposite leg is then, with the knee flexed, twined anteriorly around the affected leg, the foot being placed in tiptoe position on the floor posterior and lateral to the heel of the affected side. The free hand is placed across the chest to grasp the opposite shoulder to pull the chest downward. From this position, the patient bends forward at the hips, at the same time dropping the entire heel from tiptoe position to the floor. The action of letting the heel drop from tiptoe position helps to keep the knee of the affected side in hypertension by pressure from the crossed-over leg. This maneuver is repeated six times for each side and performed routinely three periods daily. The object is to flex the hip sharply by throwing and pulling the chest downward with a lunge. Only then is an effective, progressive, accumulative ligamentous stretch accomplished. The exercise is carried out bilaterally, because the ligamentous structures have usually contracted bilaterally, although they may not as yet have reached the contracture point of nerve impingement irritation on both sides.

Patients respond very rapidly to this type of treatment. Heel pains in many instances are relieved in two or three days. Symptoms of spastic hammertoes, cramps, Morton's toe, and metatarsalgia will usually be relieved within three to four weeks.

CONCLUSION

Many foot pains are best treated by corrective surgery.

Surgical procedures can permit the feet of style-conscious American women to conform to shoes of choice.

The industrial need of better foot care and a new shoe design that will meet requirements of safety, and at the same time be practical for work requirements, is suggested.

A not generally recognized etiologic factor, that of contracted fascial ligamentous bands as the source of impingement irritation of peripheral nerves, resulting in foot pains, is presented together with a successful method of alleviation of these symptoms by fascial ligamentous stretching to release the impingement.

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All-Union Conference on Antibiotics

On May 31–June 7, 1957, there was held in Moscow, U. S. S. R., the Second All-Union Conference on Antibiotics. The meetings took place at the University of Moscow. The Conference opened on Friday evening, May 31, at 6 P.M. The Minister of Public Health of the U.S.S.R., M.D. Kovrigina, delivered an address of welcome. This was followed by general addresses by Z. B. Ermoleva on "New antibiotics, new therapeutic forms of antibiotics and their experimental clinical significance" and by G. P. Rudnev on "Fundamental principles of the clinical applications of modern antibiotics in the treatment of infectious diseases." The concluding address at the Conference was delivered by A. P. Grishakova: "Prospectives in the manufacture of antibiotics." There were several hundred participants.

A total of 252 papers were listed. These were divided into three sections: (1) "Search for new antibiotics," 43 papers; (2) "Biology of antibiotic-producing organisms, chemistry and technology of antibiotics," 59 papers; (3) "Experimental and clinical study of antibiotics," 150 papers.

About a dozen new antibiotics were announced or discussed, in addition to many others already isolated and produced elsewhere. Practically all the new antibiotics were isolated from cultures of actinomycetes. These were designated as grisamin, actinoxantin, cerulomycin, heliomycin, celomin, crystalomycin, actinoidin, aurantin, secacin, sapropelmycin, and sapromycin. They are active upon bacteria, fungi, viruses, or neoplasms. Several forms of penicillin (benzyl, phenoxymethyl) and one fungal (poin) and one bacterial product (neocide) were also listed. Some of the isolated preparations are definitely known to be forms of well-known antibiotics. This is true, for example, of colimycin and miserin, forms of neomycin and of levomycetin and synthomycin, apparently forms of chloramphenicol; biomycin is chlortetracycline.

Considerable progress on the practical production and utilization of antibiotics was reported.

Obstetric and Gynecologic Considerations of the Foot

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As has been frequently stated, the pregnant (and, thus, inevitably the gynecologic) patient may be afflicted with all the disabilities of nonpregnant women with the addition of a few problems unique to her state. This applies to the feet as well as to the pelvis. Thus, the other discussions in this Symposium are applicable to this, and when pathology is already present, it is usually markedly aggravated by the gestational strain. The 20 pound, pedunculated abdominal "tumor" presents the most obvious alterations required in body mechanics, and the effects on the feet are readily admitted and, in most cases, fairly obvious.

From the gynecologic aspect there are both direct and indirect effects of the pelvic lesions on the feet. Directly, there are few common problems, the only practical one being that of metastases from pelvic malignancies. The results are kaleidoscopic in their localizations and, therefore, their effects, and are to be dealt with symptomatically and individually. Indirectly, one of the most important considerations is that of the soft tissue relaxations, which will produce vascular stasis and occasionally occlusive thrombosis of the pelvic great vessels. Pathogenetically, as the endopelvic fascia loses its resilience due to age, trauma, disease, or neglect, persistent perivaginal and pelvic relaxation results in descent of the pelvic contents, some of which may extend as far as 12 to 16 cm. toward the feet when the patient strains in a squatting position. As the proximal attachments of the pelvic vessels are much more firmly attached than the distal portions, there is a resultant increase in their angulation in the pelvis from a gradual "C" shape to a sharp "L" shape, especially at the base of the broad ligament, and thus a relative stasis, distally, especially of the relatively thinner-walled venous channels. This results in a crude "plugging" effect on the drainage channels from the legs, as well as the pelvic contents, with consequent engorgement. The degree of this "plugging" effect on the emptying channels of the legs determines the extent of venous and lymphatic pressure increase, distal edema, and ultimately and indirectly swelling of the feet, usually bilateral but not always equal. Symptomatology and pelvic findings substantiate the diagnosis and indicate the therapy.

Another indirect gynecologic effect on the feet is the result of the patient's attempts at seeking relief from pelvic problems by altering her posture and gait. Constricting girdles limit the range of hip motion, and thus, alterations in the heel-to-toe pressure relationships in gait result in unaccustomed ligamental and osseous strains and may produce pedal symptoms. The pain resulting from pelvic pathology results in subconscious splinting, which may manifest itself by localized foot pain, due to the altered function pattern. Perineal pads worn for a long time are a very common and indirect cause of pedal discomfort in this regard also. As most of these problems can

usually be obviated by indicated therapy, they are usually correctable in direct proportion to the duration of the pathology.

From the obstetric standpoint, we find a very interesting situation. Shakespeare immortalized the gestational biped with his phrase "pride of pregnancy gait." Complaints referrable to the feet are reported in an incidence as high as 40 per cent by some authors, and yet three active and thorough consulting sources could find only very few specific articles in the literature referring to this problem in pregnancy, and the recognized textbooks devote at most a few short paragraphs of generalities to this topic—a potential problem in each of the 130,000 deliveries occurring every day! Practically speaking, since much of the practice of obstetrics is preventive, prophylactic instruction of the pregnant patient regarding proper shoes with good arch supports, well supported broad-based heels, and comfortable walking habits, avoidance of constricting garments such as garters, and strict limitation of weight gain is invaluable. Some of the exercises advocated in antepartum care are valuable in developing adaptations of the feet.

As some 90 per cent of our American women benefit from iron and vitamin supplementation during pregnancy, in spite of our readily acknowledged dietary superiority, this is an important field of counsel, being so intimately aligned with the metabolic changes. The approximately 30 per cent increase in blood volume, one-sixth of which is occupying the low-resistance arteriovenous shunt (which, in effect, the gravid uterus becomes), adds materially to the vascular load and is readily aggravated by anemia and hypoproteinemia. Any relative decrease in protein or electrolytes results in reduced intravascular osmotic tension, and the subsequent extravasation of fluid is the main cause of peripheral dependent edema. Sodium retention is frequently augmented by the adrenal cortical hormone increase. This, plus the capillary angiospasm frequently found in some 60 per cent of pregnant women, aids the blood volume increase and its consequences.

In pregnancy, there is another very significant hormonal phenomenon, which we are just beginning to understand adequately. The British had been working on it, calling it "relaxin," and believing it to be a fraction of the progesterone complex, being produced also in the placenta. This substance has a rather specific function of producing relaxation of the pelvic ligaments, thereby loosening the joints, increasing parturient capacity, and secondarily affecting other ligamentous structures. Is it not conceivable, then, that as there is a marked variation in the amount and effect of the hormones in different individuals, so also is it not likely that this hormonal effect might extend to the pedal ligaments and aggravate pre-existing problems, or produce new strains? This is especially important in the frequently found situation of legs of different lengths.

The most common complaint, second to swelling, is that of pain induced by the exaggerated lordosis, which, in turn, is necessitated by the altered center of gravity due to the "physiologic tumor." This pain is usually most severe in the lower back, but if questioned, the patient will readily agree that there is pain in the feet, a "strain" that is much less (and thus not verbalized), but is also relieved by the very simple exercise of lying supine on a firm surface with the hips and knees in 90 degree flexion, thus flattening out the lordotic curve.

A rare complication, called obstetric paralysis, and manifest by puerperal foot drop among other things, has been attributed to either or all of the following: excessive pressure of a large fetal head on the sacral roots as they emerge through the foramen of a flattened sacrum, excessive pressure of stirrups on the perineal nerve in the region of the fibular head, or occult herniation of an intervertebral disc due to the excessive relaxation of ligaments from anesthesia, and physiologic changes allowing hyperflexion of the lumbosacral spine during the maneuvers of parturition. The prognosis in this condition is usually good, with adequate protection of the extremity during convalescence.

CONCLUSION

In conclusion, three points are to be emphasized.

1. Foot complaints in the female patient should alert the therapist to the possibility of intrapelvic disease of a gynecologic nature, which may be producing direct or indirect symptoms and in the absence of specific local lesions a thorough examination should be made.

2. Foot complaints in the pregnant woman, recognizing the obvious shift of the center of gravity and its effects, and in the absence of specific local lesions, are most commonly due to congestive or altered functional responses, the alleviation of which will clear up the symptoms.

3. Understanding of the physiologic, metabolic, and pathologic mechanisms is essential to satisfactory therapy and must be intensely individualized.

Anti-Leukemia Vaccine

Laboratory success with an anti-leukemia vaccine is reported from New York's Sloan-Kettering Institute by Dr. Charlotte Friend.

Vaccine is made from a virus that consistently caused leukemia in mice, killed in formalin by a method similar to the preparation of Salk vaccine.

The animals were given three injections at weekly intervals, then challenged with the leukemia virus at various stages. About 80 per cent of the vaccinated mice were protected, whereas some 80 per cent of the nonvaccinated animals developed leukemia within two to three weeks.

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Influence of a Flexible Outsole on the Dynamics of the Walking Gait

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In 1949, at the University of Southern California, while studying the effects of various original outsole designs on landing shock in an effort to develop an improved paratrooper boot, my associate in this research, Nathan Hack, a retired shoe manufacturer, tacked a strip of composition material onto an army boot in the form of loose folds placed in transverse parallels extending along the entire length of the sole. After several test jumps, the folds were beaten into a rearward inclination. When subjects walked in these experimental boots between jumps, they commented, "This feels like walking on air," and "These shoes seem to do your walking for you." Encouraged by such repeated observations and trial wearings by the investigators, further analyses of the new outsoles during walking were made, using time magnification by photography (filming the action at 3000 frames per second, which, when projected, shows the movement 125 times slower than the actual rate), accelerometer tests of shock at heel-strike, measurements of stride length, treadmill tests of fatigue and efficiency using physiologic measures such as oxygen consumption, heart rate, and blood pressure. In this manner, the new sole, which came to be known as the Ripple Sole,* was compared with the bare foot and conventional shoes. These analyses revealed that the angulation of the ripples offered an entirely new principle in shoe construction.

The favorable results of these tests encouraged us to proceed with refinements in the design and construction. The present model is made of molded rubber; the dimensions of the model can be observed in figure 1.

In elucidating the action of the Ripple Sole in walking, we have made concomitant kinesiologic studies of the walking gait. Some of our analyses appear in a 16 mm. sound film.† In summarizing our findings, I shall relate them in the order in which they occur during a normal walking stride.

Leg Extension Preparatory to Heel-Strike. The entire process of walking may be considered as a progression of the pelvis propelled by the rotation of the legs. The pelvis, in turn, carries the upper trunk, head, and arms. In order to keep the pelvis and its load from rising and falling unnecessarily, the lower extremity should be elongated as much as possible at heel-strike and at toe-off, and flexed to varying degrees between these events.

In the final elongation of the lower extremity at heel-strike, the knee is fully extended and the heel is projected downward by dorsiflexor contraction. Knee extension is obtained without action by the quadriceps muscle since the lower leg

* Registered trade name.

† Available from the Department of Cinema, University of Southern California, Los Angeles 7.

is carried forward by momentum at the completion of forward motion of the thigh.

At the moment of contact the foot is going backward in relation to the forward velocity of the body. In walking barefoot or in shoes with conventional rubber or leather heels, for an immediate instant after heel-strike there is a backward push of the foot on the floor; then for a considerable period of time the shear of the heel against the ground is forward, which retards forward progress. The force of this forward shear is about 15 per cent of the body weight.

In the Ripple Sole, the rearmost heel ripple accepts the backward push and then acts to convert the forward shear into forward progress. The heel ripple acts as a hinge to the ground. As the forward shearing action is commenced, the hinge closes as the ripple distorts (see figure 1). The foot is permitted to move forward, thus assisting the body to continue its forward motion and, at the same time, serving to lengthen the stride without additional expenditure of energy.

Shock at Heel-Strike. On turf or other soft surfaces the landing shock as the heel strikes the ground is absorbed by the gradual deformation of the ground surface. However, the surfaces of hard floors, sidewalks, and streets are unyielding and the bony heel of the foot is poorly cushioned by the layer of skin beneath it. Consequently, each time the heel strikes the hard ground a jarring shock is transmitted throughout the body, causing discomfort and fatigue.

The downward peak force at heel-strike is approximately 120 per cent of body weight. Thus, a 160 pound man, during a normal day's walking averaging 19,500 steps, receives 3,705,000 pounds of repeated jolts. The force at heel-strike is increased to 200 per cent in walking down an incline. The conventional street shoe with rubber heel is a slight improvement over the bare foot, but is a poor shock absorber.

With the Ripple Sole, instead of the sharp unyielding blow upon the pavement, the kinetic energy of the mass of the foot and shoe is taken up by the first wave of the ripple. The sole then distorts, absorbing the energy. An instant later, the next ripple picks up the load and distorts in the same manner. This principle cuts down the peak shock of ground contact by as much as 40 per cent.

FIG. 1. Flexible outsole action of the Ripple Sole at heel-strike.

Eccentric Dorsiflexor Action at Heel-Strike. As mentioned previously, the ankle dorsiflexors are acting fully at heel-strike in order to gain an elongation of the lower extremity. As the heel strikes the ground, tension in the dorsiflexor muscles serves to resist the tremendous force acting through the heel. This is an attempt to hold the foot approximately at right angles to the leg until the weight is transferred to the ball of the foot.

When the heel strikes a yielding surface, such as when Ripple Soles are worn, the dorsiflexor muscle action is effective in resisting the rotational force at heel-strike and the ball of the foot is gradually lowered to the ground against an eccentric contraction of the dorsiflexors.

When the heel strikes a hard surface, however, the pretibial muscles fail to meet the demand and the forward rotation of the foot is quickened. The ball of the foot then strikes with an impact great enough to produce a second jarring effect. The quickened rotation and double shock upset the timing of the foot action, and increased muscular activity is required for support and for propulsion.

The use of Ripple Soles is indicated on track and basketball shoes in early season training to reduce the incidence of myositis ("shin splints") caused by running on a hard surface and continual jarring.

Jackknife Action at Heel-Strike. At heel-strike the upward force from the ground is transmitted through the extended lower extremity. The femur pushes up and back against the acetabulum, which would result in an undesirable anterior rotation of the pelvis were it not for the reverse action of the hip extensor muscles.

The forward momentum of the trunk tends to carry it forward over the pelvis at heel-strike. There is also a tendency for the head to be rotated forward. The factor of inertia is counteracted in the thorax by the action of the lumbar extensor muscles. The head is kept back over the thorax by the action of the neck extensors.

The stabilizing action of the large muscles throughout the body in controlling the jackknife action at each step undoubtedly makes a large contribution to the energy cost of walking. The pendular action of the legs requires very little muscular effort; yet walking in conventional flat-soled footwear requires a fourfold increase above the standing metabolic rate. When Ripple Soles are worn, an individual's energy cost of walking is reduced about 10 per cent.

This consideration of the muscular response to the jarring effect of the heel-strike may offer an explanation for the incidence of low back and neck aches among persons who have been walking on hard surfaces wearing hard leather heels or going barefoot.

Shock-Absorbing Actions at Heel-Strike. Three joints, the knee, the ankle, and the subtalar joints, are involved in absorbing the shock at heel-strike. The knee is fully extended at heel-strike and flexed 15 to 20 degrees in helping to absorb the impact. The elasticity of the pretibial muscles provides some shock-absorbing effect at the ankle, but, as explained previously, the foot is normally maintained at a right angle to the lower leg at heel-strike. The subtalar joint between the talus and the calcaneus permits a gliding action to attenuate the shock to the foot.

The subtalar gliding action also permits an adjustment of the angle between the leg and ground surface either when the leg is in an abducted or adducted position in

walking or when irregular ground surfaces are traversed in walking. Ripple Soles assist in stabilizing the foot and act as a fourth shock-absorbing joint.

Inward Foot Rotation at Heel-Strike. Prior to heel-strike the pelvis rotates forward about 5 degrees on the side of the swinging leg. The femur and tibia, swinging forward, rotate inward even faster and through a greater range. At the time of heel-strike the inward rotation continues, producing a lateral thrust of the foot on the floor amounting to about 7 per cent of body weight. At foot-flat all these rotations are reversed. In the Ripple Sole, the hingelike action of the transverse heel ripples tend to counteract this wasteful rotatory action.

Propulsive Action at Mid-stance. In walking barefoot or with conventional shoes, the foot is fixed to the ground during the period of support. A large part of the forward momentum is dissipated as the foot is pressed forward until the leg is past the perpendicular position. No part of the energy lost from this dissipation of momentum is recovered. However, this loss must be compensated by the action of the hip extensor muscles in driving the pelvis forward on the leg up to mid-stance. During the foot-flat phase, the torso is being held erect, and in the middle of the stance there is a straight downward force of about 80 per cent of body weight.

The Ripple Sole, which provides a continuous even tread from heel to toe, distributes the weight along the entire foot, not at the heel and ball only as in conventional flat-soled shoes. The supporting action of the Ripple Sole stabilizes the foot and assists in maintaining balance. In addition, during the weight-bearing phase of the walking stride the ripples are depressed. During the bending action of the ripples there is a forward gliding action, the second phenomenon that contributes to the lengthening of stride without energy cost. The energy stored in the first ripple begins to flow back into the foot, propelling it forward. This action continues from ripple to ripple until the toe leaves the ground. It is this feature that causes the sensation that "the ripples are doing some of the walking for you."

Propulsive Action at Heel-Rise. When the tibia is rotating around the astragalar axis and the foot is flat on the ground, the calf muscles are put on a stretch, which improves their condition for action. As the tension of the calf muscles increases, the force becomes great enough to fix the foot on the tibia, thereby raising the heel and shifting the pivotal point forward to the metatarsophalangeal joint. The pelvis continues to move forward and is well ahead of the foot at heel-rise. If the calf muscles act too early or too strongly, their action on the foot would lift the body upward rather than propel it forward.

The knee, which has been partially flexed at mid-stance so that the pelvis does not have to climb up and over an extended extremity, again becomes extended after mid-stance as the heel rises from the ground. The knee becomes straight just before push-off, thereby imparting to the pelvis the propulsion gained by plantar flexion of the foot and driving it forward. In this manner, the driving force is not wasted by absorption in knee flexion.

The increase in weight on the ball of the supporting foot elicits the "stepping reflex," which causes contraction of the extensors of the ankle and hip and results in a propulsive thrust forward and upward. The elevated heel, provided by the one-half inch wedge, raises the shaft of the calcaneus at a 90 degree angle to the Achilles

tendon, thereby enabling the gastrocnemius and soleus to exert greater force in plantar flexion. Julius Caesar recognized this advantage 20 centuries ago when he observed that his legions could march farther when the heels of their sandals were elevated by a leather platform. In running, however, foot plantar flexion is more forceful and occurs over a longer range. Thus, the running shoe permits the heel to rest closer to the ground.

Sole Flexibility. If the foot and shoe cannot operate as a unit in walking, additional muscular action is required of the foot, and the independent action of the shoe against the foot becomes abrasive. The shoe should be retained snugly against the heel and the sole should be flexible, allowing the joint actions described previously to take place. Furthermore, the portion forming the instep should not interfere with ankle flexion.

A conventional one-half inch thick rubber or composition sole of the same thickness from breast of heel to tip of toe is relatively inflexible and requires muscular effort to bend it at each step. A Ripple Sole with 17 ripples provides 16 flexible hinge points at which only the backing is required to bend. Since the backing between ripples is only one-eighth inch thick, its flexibility permits the shoe and foot to act together.

Toe Action in Push-off. As the heel leaves the ground in plantar flexion, the weight of the body is transferred to the ball of the great toe. The toes, apart from the great toe, are chiefly concerned with balance. On soft surfaces the toes press downward and serve as a fulcrum at toe-off. As the toes press downward the medial component of the foot is depressed and the great toe is flexed to give the final push-off. The backward force is about 20 per cent of body weight at the time of push-off.

On a hard surface, either barefoot or in a shoe with a firm flat sole, the toes are forced into dorsiflexion before toe-off and in this position are unable to act in the final push-off. The ball of the foot thus becomes the fulcrum and the extra leverage ordinarily afforded by the toes is lost. The flexibility provided by the foremost ripple of the Ripple Sole allows the toes to act somewhat as they would in soft ground, serving as an extended lever and thereby making a third contribution to the lengthening of stride.

Knee Flexion at Push-off. Immediately after heel-rise, the hip and knee flex with the result that the final portion of the push-off assists in moving the leg forward at the beginning of the swing phase. Once the knee has flexed, further pressure of the toe on the floor only pushes the knee forward and does not serve to push the pelvis forward.

When Ripple Soles are worn, at the end of the period of support the energy stored in the compressed ripples is released and the elastic force of the return to resting shape gives assistance in raising the foot from the ground and helps to propel the foot forward. This release of kinetic energy is the fourth action that Ripple Soles contribute to the lengthening of stride. The combined four factors in Ripple Sole action increase the stride 6 to 8 inches over that when conventional shoes are worn. The gain in stride achieved without extra effort improves efficiency in walking and reduces fatigue.

Additional Features of the Ripple Sole. In addition to the several contributions that

Ripple Soles make to comfort, efficiency, and reduction of fatigue in walking, as described previously, other features have been noted in further laboratory and field tests. They are as follows.

(a) In tasks requiring quiet standing, the flexible Ripple Sole encourages slight motions in the feet and toes in excess of that occurring under similar conditions in conventional shoes. Such motions promote the milking action of the muscles and thus prevent pooling of blood and lymph. The improved circulation resulting from the use of Ripple Soles is of special value in cardiac insufficiency and arthritis.

(b) The shock-absorbing action provided by the shape of the ripples makes the Ripple Sole an added protective feature of industrial safety shoes. The force of a crushing blow to the foot is partly attenuated by the bending of the flexible ripples.

(c) The conformation of the ripples is such that Ripple Soles absorb vibrations and shocks from floor surfaces and decks, thereby protecting the wearer from fatigue and injury in such conditions.

(d) A nonskid feature results from the flexible multiple surfaces, which offer more traction than hard, smooth-surfaced one piece outsoles. Ripple Soles are thus advantageous in climbing grades and working on slippery surfaces.

(e) Feet are protected from hot or cold floor surfaces by the interspaces formed by the elevated ripples. These interspaces provide ventilation and insulation against temperature transfer. The ventilating feature of the Ripple Sole also prevents the foot from becoming overheated, as is sometimes experienced in wearing a solid rubber sole.

(f) On wet surfaces the feet ride on the ripples above the water. Ripples do not absorb moisture and they dry quickly.

(g) The ripples, being wider apart at the tips than near the sole, tend to extrude pebbles and other foreign matter. The flexibility of the Ripple Sole also contributes to the self-cleaning action.

The Ripple Sole makes several significant contributions to human locomotion in modern city living. Its shock-absorbing and motility features serve to turn the hard surfaces to advantage in walking. The function of the human foot, including toe action, is allowed to operate in a normal manner when Ripple Soles are worn.

The Ripple Sole is now available on duty and casual shoes for men, women, and children. It is being used experimentally on military, industrial, athletic, and orthopedic footwear.

Orthopedic Disabilities

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Analysis of foot function requires consideration of the problems of weight-bearing stability simultaneously with those of motion. A toe dancer, in whom the long extensor of the great toe attaches to the distal phalanx, is able to stabilize on her toes without the aid of box shoes, whereas if the attachment is to the proximal phalanx, the interphalangeal joint will give way and she will need box shoes to stabilize on her toes. A limitation of motion in only one joint, as, for example, dorsiflexion of the great toe at the metatarsal phalangeal joint (hallux rigidus), may seriously handicap walking by preventing weight-bearing on the metatarsal heads area, because the great toe cannot dorsiflex to get out of the way. Fixed plantar-flexed hammertoes produce a similar disability.

The wearing of shoes,[1] mass-produced to fit every foot and hence fitting none, constricts the foot so that any deviation of the foot produces a wear and tear friction pressure of the skin and subcutaneous tissue over the bony prominence deviation, hence, callosities over the dorsum of the interphalangeal joints in dorsal hammertoes, over the tips of the toes in plantar flexion hammertoes, under the abnormal protrusion of one or more plantar condyles of heads of the metatarsals (metatarsal plantar callosities often mistaken for plantar warts), over the abnormal prominence of the head of the first metatarsal (bunion), over the abnormal prominence of the head of the fifth metatarsal (tailor's bunion), over an abnormally prominent base or head of the phalanx between the toes (soft corn), over a sesamoid.

Aids to foot-balancing of the weight-bearing, by means of various types of foot plates, arch supports, metatarsal pads, tilting wedges at various locations of the sole and/or heel of the shoe, metatarsal bars across the shoe just back of the metatarsal heads, and felt padding to remove pressure from affected areas, have a place in therapy, but definite relief requires whittling the foot down to fit a shoe.

Excision of an interphalangeal joint is an accepted procedure for relief of fixed hammertoes. Excision of the bony prominence underlying bunions, tailor's bunions, soft corns, and plantar callosities[2–4] is the operation of choice.

In the operation for a bunion, the proximal half of the first phalanx of the big toe should also be removed (which removes the attachment of the adductor of the big toe as well) in order to correct the associated tendency of the big toe to go into hallux valgus with crowding of the lesser toes.

In certain instances of bunions there is a condition present known as splayfoot in which the first metatarsal deviates in contour medially, producing a wider space between the heads of the first and second metatarsals and, hence, an abnormally broad metatarsal area impossible to fit into any shoe. This deviation of contour of the first metatarsal may be corrected by the Billig impaction type of telescoping osteotomy,[5] which cannot become displaced even though no internal fixation is used, or by the Lapidus plastic operation[6] at the tarsal-metatarsal joint. The disadvantage of the latter is that it disrupts a weight-bearing joint in which motion

must be maintained and later development of traumatic arthritis is a hazard.

Congenital clubfeet are characterized by three components: forefoot adduction, talipes equinus (plantar flexion contracture, "short heel cord"), and talipes varus. The condition should be recognized as early in infancy as possible and, in the infant, can be easily corrected by means of traction to eliminate all three components. This is done by winding one-inch wide strips of adhesive tape, starting from the dorsum of the foot, then medially to around the plantar surface, then dorsally across the dorsum to extend onto the medial aspect of the lower leg just above the ankle. If a sharp pull tension is maintained on the adhesive tape during its application, the foot will be moved in the direction of correction of all three components of the deformity. In order to help force the foot in the direction of correction, the mother is taught to hold the baby's forefoot between her thumb and forefinger, twisting outward and dorsiflexing, meanwhile exercising stability by holding the lower leg with the other hand. This manipulative stretching traction, by the mother, must be done many times daily, with renewal of the adhesive strapping every few days, and thus a progressive restoration of normal position, by elimination of all three components of the deformity, is obtained. If the deformity is too fixed, or if the child is allergic to adhesive tape, the foot is forced into maximum correction and a plaster cast applied for one week, after which the cast is replaced by another, again forcing the foot into maximum correction. This is repeated until the proper position has been obtained, after which the manual manipulation must be continued, sufficiently daily to prevent recurrence. When the child is old enough to do the manipulative stretchings himself, he can be taught exercises to continue it until full growth is obtained; otherwise the clubfoot deformity will recur. It is well to remember that the stability counterpull of the "heel cord" is very helpful in correcting the forefoot adduction and talipes varus components, so that unrestricted heel cord lengthening will not only destroy the power of the calf muscles, but will defeat the manipulative correction as well. Clubfoot shoes are obtainable, but if expense is a consideration, the ordinary pair of shoes reversed right for left serves admirably as an aid in maintaining correction. Certain recurrent cases (chiefly due to neglect or lack of cooperation) may later need surgical orthopedic foot correction by means of fusion of certain joints, at the same time performing a wedge osteotomy to gain correction of position. This also may be necessary for the so-called "rocker foot," when the repetitive pressure under the metatarsal area toward dorsiflexion in the corrective manipulation stretch has caused the tissues to give way in the plantar aspect, instead of pulling the heel with them into correction, as should have happened.

Metatarsus adductus, without the other two components of clubfoot, is an innocuous, congenital, unilateral or bilateral condition rarely needing corrective treatment other than proper size shoes. This condition should not be confused with the unfortunate clubfoot.

At times, a condition similar to clubfoot will be found in a person with spina bifida. In such cases caution must be exercised to prevent a possible trophic pressure ulcer where the adhesive or plaster presses on the foot in correction. In fact, there is reason to believe that the ordinary clubfoot may be the result of some abnormality of innervation similar to the spina bifida type.

In both genu valgum and genu varum and in old angulated malunion of fractures, if the deformity is sufficient, the thrust in weight-bearing motion on the foot is productive of an impossible mechanical situation, so that some one of the various types of surgical osteotomies[5] to correct the contour of the leg must be performed. The site of osteotomy, usually either femoral, just above the knee, or tibial, just below the knee, is dependent on the locale of the chief deformity and must be carefully selected.

There are a number of conditions producing a relative actual short leg resulting in abnormal foot stresses. These include fracture shortening in tibia or femur, coxa vara or coxa valga, trophic relative undergrowth in length in poliomyelitis. If the relative length difference is not great, raises of the heel or heel and sole of the shoe will equalize the legs. A relative difference of two inches or more presents the question of doing either a leg lengthening of the femur or tibia of the short leg or a leg shortening of the femur or tibia of the longer leg. These operations are technically complicated, frequently bringing in their wake the complication of nerve, trophic, and vascular disturbances, nonunion or repeated fractures at the osteotomy site, distortions of the foot, and aberrancies of balance of muscle function. Hence they have not been too widely in favor.

Aberrant growth may be due to epiphysial injury from trauma, sometimes associated with fractures near the epiphyses, or a result of overgrowth due to increased blood supply to a part of the epiphyses in bone infections, or a deficiency of growth of one side of the epiphysis due to an osteochondroma "bleeding" away part of the growth potential on that side. It is important to correct these conditions as early as possible by clearing up the osteomyelitic bone infection, excising the osteochondroma (including the base), or replacing an epiphysial fracture displacement accurately and early; otherwise, an osteotomy may later be necessary to correct an abnormal bony angulation.

Apparent leg shortening may be due to a congenital dislocated hip with abductor (gluteus medius, Trendelenburg) limp or a weakness in the gluteus medius (most commonly poliomyelitic, but also due to other dystrophies at times) or fracture of the neck of the femur.

At times, the problem of function of the foot is complicated by a degenerative process of the hip known as malum coxae senilis, preventing proper positioning of the hip and leg for correct weight-bearing of the foot; unless the hip function can be regained by some such arthroplastic operation as, for example, a prosthetic artificial head of femur insertion, the corrections lie in adjusting the weight-bearing contour of the sole and heel of the shoe to fit the position necessary.

Epiphysial hip injuries and fractures and Legg-Perthes disease have a tendency to produce, in later years, a picture often indistinguishable from malum coxae senilis due to other causes. There is a tendency in chronic arthritis for the leg to go gradually into a flexion, adduction, and external rotation deformity position at the hip, thus causing the foot to be carried along rotated outward, and in walking, the foot will roll over its medial border. Correction of foot contour here must be approached with caution. Attempts to raise the "medial longitudinal arch" by means of foot appliances will only lend to pressure pain, since, because of the hip condition, it is

necessary for the individual to compensate by rolling over the medial border of his foot in order to be able to walk at all.

Correction of an abductor (gluteus medius, Trendelenburg) limp by changing the relative length of the leg through raises on the heel and sole is a tricky undertaking. The first impulse is to raise the side toward which the body jerks in weight-bearing. This is, however, the side on which the gluteus medius is not capable of performing its function, so that the raise may only aggravate the limp, and it is often a raise of the opposite side that will aid the most in enhancing total function.

Extension "locking" of the knee, so as to make it secure in weight-bearing, is important for many persons with weakened musculature (from poliomyelitis, for example). In such instances the balance between height of heel and sole of shoe is all-important. Raising the heel too high will tend to make the knee "break" in weight-bearing. This point becomes very important when there is an associated short leg, and adding shoe raises, also to correct for this, is contemplated. Analysis of muscle function in an extensive series of patients with postpoliomyelitic muscle weakness, at the California Institute of Technology,[7] revealed that, of the total amount of normal power divided between the hip extensors, knee extensors (femoral group), and foot plantar flexors, two thirds of such potential power had to be retained by the individual in order to provide stable knee-extension function in weight-bearing and to prevent the knee from "breaking," causing the individual to fall. For example, should the femoral group extension power be zero but, however, the hip extension and foot plantar flexion power be normal, the individual will be able to hold the knee stiff (even without locking the knee) in full weight-bearing. In such individuals, even a slight raising of the heel height reduces part of the useful power of plantar flexion at the necessary arc of weight-bearing motion at the ankle and prejudices the knee stability. The previously illustrated importance of simultaneous backward pull of the femur by hip extensors and backward pull of the tibia by the foot plantar flexors, in maintaining knee-extension stability during weight-bearing, cannot be overemphasized.

Uncontrollable plantar flexion and lateral deviations of the foot in spastic conditions (Little's disease, spastic hemiplegia, etc.) are very disturbing handicaps that can frequently be markedly aided by stabilizing the foot with a Hoke (triple arthrodesis) operation, consisting of fusion of the subastragalar, astragaloscaphoid, and calcaneocuboid joints.

Increasing foot deformity, secondary to poliomyelitis and other causes during growth and development, is usually approached by adjusting raises on the plantar weight-bearing surface under the points (vectors) toward which the deformity trends. This is calculated to reduce the abnormal drift, by forcing the foot toward correction, and is a different approach from "normal" foot-balancing raises. In the latter, the raise is placed on the opposite side to equalize the sole of the foot with the weight-bearing portion of the shoe in order to distribute the pressure.

The nervous system has a remarkable ability to adjust its control of balance of power of muscles so that, when aberrant muscle pull due to poliomyelitic, spastic, or other impairment of power ensues, it is possible to shuffle the tendon attachments of the muscles to the foot to new locations in order to effect a new corrective balance

of useful power. The tibialis anticus, tibialis posticus, peroneus longus, or peroneus brevis may be "transplanted" to the dorsum of the foot or Achilles tendon, as the condition requires, and will perform admirably, provided that the muscle of the tendon transplanted has at least fair power before transplanting and provided the muscle is "pulled" out to its useful length in reattaching at the new position, so that it can provide its power in the useful arc of motion and not flop loosely. In weakness of dorsiflexion there is frequently an attempt by the E.P.H. (long big toe extensor) to help, resulting only in a cockup of the big toe, creating further difficulty with the encasing shoe. This can be turned to advantage by transplanting the tendon attachment of the E.P.H. from the toe to the first or second metatarsal, to then aid in dorsiflexion. When a muscle has useful power, but at the wrong arc of motion because of being abnormally "stretched out," it may be restored to usefulness, at the efficiency arc, by means of simple shortening of the tendon.

In instability of the foot, due to extreme muscle weakness, or when there is incapacitating bony deformity, the triple arthrodesis (Hoke), with or without correcting wedge osteotomies as indicated, is a very fine standard operation.

Often, in medial semilunar cartilage and medial lateral ligament knee injuries, after reduction of the cartilage displacement, if present, a one-fourth inch wedge raise of the medial border of the heel of the shoe will provide considerable comfort and aid materially in prevention of recurrence. This wedge should be worn at all times for six months or more.

Shortening of the posterior muscle group, known commonly as "short heel cords" preventing dorsiflexion of the foot, is often secondary to contraction of the fibrous tissue (sarcolemma, etc.) in these muscles. The unopposed position of talipes equinus with high heels is a factor encouraging this condition. It has been suggested that raising the heel of the shoe to accommodate to this position is advisable; however, this results in a dead end vicious circle. The proper approach for long term correction is to re-establish progressively and accumulatively proper length by means of repetitive stretchings. A simple stretching exercise is to stand 18 inches from and facing a wall, fold the arms against the wall, and then bring the pelvis toward the wall keeping the knees straight. If the contracture is severe enough to pull the heels off the floor, "bouncing" gently to make the heels approach the floor will aid materially at each stretching period.

There are many instances of "joint stiffness" as, for example after immobilization following injury, arthritis, and healing after fractures, that can be markedly improved by mobilization of these joints. It is known that, in order to obtain a bending, flexing, or extending motion, there must also be present first a degree of uncontrolled (also known as gliding or slipping) motion allowed by proper laxity of the joint ligaments and capsule. Progressive accumulative restoration of this motion, by means of repeated Mennell[8] type joint manipulations, results in an amazingly satisfactory automatic concomitant restoration of the bending, flexing, and/or extending motion. Manipulative loosening of stiff joints can be materially aided by local injection of hyaluronidase, cortisone etc.

Proper function of the foot entails a stabilizing effect of certain muscles controlling plantar versus dorsiflexion and eversion versus inversion, while, at the same time, the

take-off is enhanced by the forward thrust of plantar flexion of the toes. Unfortunately, the use of shoes has resulted in almost universal loss of use of this function of the toes because the toes are held in a position in which they cannot perform. In the short dash events of track, where maximum performance can be fairly measured, a marked improvement in "time" can be obtained by teaching the individual to use his toe plantar flexion aid in take-off and thrust throughout the entire dash. A good illustration of this is in handstands where the wrist muscles act as balance stabilizers and the finger muscles furnish the take-off. All too frequently the entire take-off is from the ball (metatarsal head) level of the foot with total disregard of the toe plantar flexors.

It must be remembered that infection of foot or toe blisters or cuts, apparently only local and inconsequential and healing rapidly, may be followed by a few bacteria traveling up the leg as a lymphangitis to enter the blood stream, with resultant blood stream infection. These bacteria, particularly in children may then land, two to three weeks later, in the end-arteries near the epiphysial line of long bones, producing osteomyelitis. It is for this reason that such blisters and cuts should be taken seriously and treated with adequate antibiotic therapy. The death of President Coolidge's son brought this forcibly to general attention.

Certain fractures of the foot require meticulous care because weight-bearing, as well as motion, aggravates the irritation of any mechanical malalignment of the joints and tends to produce a subsequent traumatic arthritis, growing more disabling year by year.

Fracture of the medial malleolus, if the process is not displaced or separated, will heal if the foot is immobilized in strong inversion. If the process is displaced or separated, surgical open "pegging" by nail or screw is required. Fracture of the lateral malleolus (fibula) is often slow to heal and, although by itself not mechanically disabling, will form a source of chronic irritation until healed. Fracture of the posterior lip of the tibia, accompanying fractures of the medial and lateral malleolus (Cotton or trimalleolar fracture), is frequently overlooked. In all fractures of the malleoli, it must be ascertained whether or not there is any degree of lateral dislocation of the foot at the ankle, and if there is, it must be reduced. The mortise of the ankle joint maintained by the medial and lateral malleoli ought, in all instances, to be restored to normal, or else subsequent severe disability is sure to follow. In fact, adhering to the old adage "Never let the sun rise or set on a dislocation" avoids much serious concomitant nerve and blood vessel damage.

Fractures of the neck of the astragalus occasionally occur and tend not to heal due to poor blood supply, so that it may be necessary later to remove the unhealed fragment of the head to eliminate the chronic irritation.

Marginal joint ligament avulsion fractures are fairly frequent, particularly at the dorsum of the tarsal joints. These usually heal, but if a marginal fragment persists unhealed, it will provoke chronic irritation and should be removed.

Fractures of the metatarsals in their shaft resemble those of other long bones and need to be aligned as best possible and held by adhesive foot-strapping with cautious weight-bearing until united.

Fractures of the metatarsals just behind their heads present a problem of major

importance since the distal head fragment tends to turn downward into the sole and, if left there, will heal to the shaft fragment in that position, producing a "lump" on the sole of the foot that makes weight-bearing a constantly painful event. The distal fragment needs to be elevated and rotated into alignment and held there. This often requires open surgical internal manipulation, and considering the extreme importance, there should be no hesitancy to do so. Fractures of toes are frequent and require, in treatment, chiefly realignment and adhesive strapping to an adjacent toe, with care taken to place some gauze between the toes to prevent the maceration of skin-to-skin approximation. Fractures of the heel (os calcis) often extend into the subastragalar joint and usually produce a sagging of the mid-portion of the calcaneal contour, throwing the approximation of the various calcaneal joints out of alignment. Many methods of treatment to restore the normal contour of the calcaneus, in setting (reducing) these fractures, have been proposed, but the end results are still very poor. A marked reduction of "time-off-duty disability" and of percentage of "residual permanent disability" can be effected by recognizing this at the outset and performing a subastragalar (some orthopedists believe a triple) arthrodesis at the time of the initial treatment.

There are many less common conditions affecting the foot, each of which requires its own specific care, e.g., syphilis of joints (Charcot joints) and bones with or without tabetic loss of ankle reflex and proprioceptive positional sense, pernicious anemia causing loss of vibratory sense, multiple sclerotic paresthesias and disorders of neuromuscular control, spinal cord and peripheral nerve injuries, neuromuscular dystrophies, poliomyelitis and Guillain-Barré variations in muscle power, tuberculous and other infection of the joints and bones, bone cysts and tumors, vitamin deficiencies, such as scurvy, rickets, pellagra, and beriberi, frost-bite.

Wounds of the feet are frequent and often raise the question of tetanus and gas bacillus infection, since the source of these wounds are often the ground or possibly manure-contaminated objects. Adequate tetanus and gas bacillus antisera should always be used, after first, of course, testing the patient for allergic sensitivity (intradermally).

Pain and swelling along the course of a tendon, with increase of pain on use of the tendon, and a feeling of sensation of crepitation when palpating the tendon during its use, indicates a tenosynovitis. This may be purely mechanical in nature following overuse, or may be a result of localized irritation of the tendon sheath, as in gouty conditions. Rest, roentgen therapy, adrenal corticoids, and colchicine[9–17] are the most commonly used. Occasionally the tenosynovitis may be of infectious origin, either acutely septic, requiring surgical drainage only if antibiotics fail to cure it, or chronically septic, chiefly tuberculous. The latter may be suspected when, after adequate treatment, the synovitis persists. Certain drugs have recently been evolved as aids in the control of tuberculosis.

In this presentation, attention has been called to a few of the more frequent orthopedic disabilities impairing the function of the foot.

In the papers presented in this Symposium on the foot by the members of this panel there have been discussed a great many conditions, factors, and therapies.

All these papers taken together will, we trust, leave the reader with a fairly well-

rounded understanding of that frequently neglected "foreign body," the pedal extremity.

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In the September issue of the International Record of Medicine:

The Phrenotropic Agents by C. Jelleff Carr and William J. Kinnard, Jr.; *Dextro-Amphetamine Sulfate in Mild Depression and Anxiety* by Edward Settel, M.D.; *The Hippocratic Oath* by Douglas Guthrie, M.D., F.R.C.S.; *How Hippocrates Made His Diagnoses* by Ralph H. Major, M.D.; *Preliminary Observations on the Positive Inotropic Effects of Mephentermine* by Harold J. Freiheit, M.D.; *Prednisolone: A Preliminary Appraisal of Its Use Topically* by Albert A. Soifer, M.D.; *Pharmaceutical Research* by Morris Fishbein, M.D.; *Quarterly Review of Ophthalmology*.

BOOK REVIEWS

Clinical Laboratory Methods. W. E. BRAY. St. Louis, C. V. Mosby Co., 5th ed., 1957. Pp. 731. 124 illustrations and 18 color plates. Price $9.75.

Although the format of this edition of *Clinical Laboratory Methods* is conveniently smaller than previous ones, content has not been sacrificed. As before, interpretations of laboratory findings are under the heading "Significance," and formulas for reagents are collected in one chapter.

New in this edition are charts of findings in the blood of normal children and illustrations of lupus erythematosus cells and rosettes, plasma cells, actinomyces in exudate, and the *Gordius* species of roundworm.

Additional material includes the status of the Salk vaccine, radioactive iodine and protein-bound iodine in the diagnosis of thyroid disorders, transaminase, cation exchange indicator, anticholinergic drugs, the treponema immobilization test, epidemic hemorrhagic fever, cat scratch disease, the neutral red indicator test for virulence of the tubercle bacillus, doubly refractile lipoids in urine, pseudoalbuminuria, the sex difference in nuclei of mature granulocytes, and the male frog test for pregnancy.

This volume is an excellent source for the more recent information and the most frequently used methods of laboratory diagnosis. The product of the author's long teaching and supervising experience, the book should be particularly valuable to medical students and clinical laboratory technicians.

Dorland's Illustrated Medical Dictionary. 23rd edition. Edited by LESLIE B. AREY, WILLIAM BURROWS, J. P. GREENHILL, AND RICHARD M. HEWITT. Philadelphia, W. B. Saunders Co., 1957. Pp. 1598. 700 illustrations and 50 plates. Price $12.50.

Formerly named *The American Illustrated Medical Dictionary* and renamed in this twenty-third edition to accord with the title familiar to generations of physicians, this volume reflects the many recent advances in medicine, surgery, and allied sciences by the addition of thousands of new terms and the revision of many older entries. The table of modern drugs and dosages has been revised and enlarged, the anatomic tables have been entirely rewritten, and the section on fundamentals of etymology, introduced in the twenty-second edition, appears again at the back of the book. New features include a table of contents and notes on the use of the *Dictionary*. The latter covers arrangement of entries, alphabetization, pronunciation, the formation of plurals, etymology, and abbreviations.

Prepared by four editors and 47 consultants and major contributors, with the help of 25 other authorities whose comments contributed to the revision of the material, this edition of *Dorland's* lives up to its original aim of producing "in a volume of convenient size, an up-to-date medical dictionary sufficiently full for the varied requirements of all classes of medical men."

SPIROCHETE IDENTIFIED IN MULTIPLE SCLEROSIS CASES. The microorganism Spirochaeta myelophthora was identified in 59 of 76 cases (78 per cent) of multiple sclerosis in tests of spinal fluid by bacteriologist Rose Ichelson (Proc. Soc. Exper. Biol. & Med.). The spirochete was not found in 28 controls; Miss Ichelson is convinced that it is the cause of multiple sclerosis.

NEW THERAPY DEVELOPED FOR PENICILLIN REACTIONS. Injection of a newly developed penicillinase gave highly successful results in treatment of penicillin reactions, reported Capt. G. M. Davis and Dr. R. M. Becker at the A.M.A. convention in June. Dramatic relief occurred within a period ranging from a few hours up to 24 hours, most patients being completely free from itching and swelling in 24 to 72 hours. Penicillinase will be introduced under the trade name Neutrapen (Schenley Laboratories) before the end of the year.

RARE PARATHYROID TRANSPLANT PERFORMED. A rare surgical transplant, in which four parathyroid glands were successfully transferred from a stillborn baby to a 36 year old veteran, was performed by Dr. George L. Jordan, Jr. (Veterans Administration Hospital, Houston). Both the thyroid gland and the parathyroids were transplanted, but only the parathyroid glands survived. The operation, performed only three times before, was necessitated when the veteran developed a reaction to parathyroid extracts administered after his own glands were removed eight years ago because of cancer.

ABSENTEEISM COSTS PRIVATE INDUSTRY TWO BILLION. Employees' prolonged illness and absence from work cost private industry almost $2,000,000 in production time annually, according to a five year study by the Research Council for Economic Security. Diseases affecting workers most were those of digestive system (23.6 per cent) and circulatory system (12.9 per cent). Accidents, poisonings, and violence accounted for 11.1 per cent.

NEW ARTIFICIAL KIDNEY. A new artificial kidney is being used at University Hospital, Ann Arbor, Michigan, for patients with acute temporary kidney failure. The device, known technically as an extracorporeal hemodialyzer, tides the patient over critical period by "washing" poisonous waste products from the body or removing excess fluid from the blood that has accumulated as a result of kidney fail-

ure. The artificial kidney can be connected to a vein or artery in the arm, is composed of a series of cellophane layers that allow waste products to pass out of the blood and important lacking substances to be replaced to the blood.

CAUSE OF HIGH BLOOD PRESSURE BELIEVED DISCOVERED. A chemical substance, hypertensin, has been isolated in the human blood stream and is believed to be the cause of high blood pressure, report a research group at the Veterans Administration Hospital, Cleveland. The researchers are now seeking a chemical agent that will counteract hypertensin.

RECOMMEND VITAMIN B_6 WITH ISONIAZID. Importance of addition of vitamin B_6 to diets of patients being treated with isoniazid received support from findings of Dr. Richard W. Vilter (University of Cincinnati) reported at the A.M.A. convention. Addition of vitamin B_6, he says, "will prevent the peripheral neuritis which occurs in about 3 per cent of patients treated with average doses of INH and in 40 per cent of persons receiving 20 mg./Kg."

ANTIBIOTIC EFFECTIVE AGAINST SURGICAL INFECTIONS. Oleandomycin tetracycline (Pfizer trade name: Sigmamycin) was described as "very effective in staphylococcic infections" in a report on its use against 50 surgical infections (J. South Carolina M. A. 53:no. 5, 1957). The drug was responsible for controlling 47 of the 50 infections and was well tolerated by the patients, good results being obtained with oleandomycin tetracycline in cases where both penicillin and sulfa drugs had failed to control infection. Study covered 29 cases of soft tissue infections (carbuncles), 10 wound infections, 6 postoperative contaminations, 3 cases of acute appendicitis, a severe burn, a severe inflammation of the pharynx.

INTEGRATING MECHANISM OF BRAIN STUDIED. A tiny structure in the brain stem, called the RAS, has been suggested as the integrating machine of the brain, according to studies by Dr. John D. French (Long Beach Veterans Administration Hospital). The RAS awakens the brain to consciousness, keeps it alert, directs traffic of messages in nervous system; it monitors the many stimuli that beat on our senses, accepting the necessary and rejecting the irrelevant, and it also tempers and refines muscular activity and bodily movements.

ATOPIC ECZEMA CONTRAINDICATION TO VACCINATION. The importance of atopic eczema as a contraindication to smallpox vaccination has been emphasized by a 1230 case study at Duke University. There were 8 cases of eczema vaccinatum, 1 fatal, in the series, and it is urged that vaccination not be given to persons with atopic eczema and to others in close contact with them.

An Appraisal of a New Antiemetic Drug: Prochlorperazine

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While it is undoubtedly extremely important to establish the etiology of nausea and vomiting, the immediate control of such symptoms is also important in order to make the patient amenable to diagnostic procedures and to institute definitive treatment. Whatever the origin of symptoms, the prevention of discomfort and debilitating dehydration resulting from protracted, severe vomiting often presents to the practicing physician one of the greatest challenges to his ingenuity.

These considerations led me to evaluate a new antiemetic and ataractic agent, prochlorperazine,* recently reported to provide rapid, efficient control of nausea and vomiting of advanced cancer and other chronic diseases.[1] Preliminary investigation has shown that prochlorperazine has two to six times the antiemetic potency of chlorpromazine in reversing apomorphine-induced emesis in dogs.[2]

METHOD

In order to give as extensive an appraisal as possible, I used this compound in suppository, tablet, and injectable forms in a wide variety of conditions in which nausea and vomiting were either present or imminent. I selected 127 ambulatory and hospitalized patients at random (37 male and 90 female patients ranging in age from 8 months to 85 years). In addition to nausea and vomiting, symptoms of agitation, anxiety, tension, nervousness, depression, diarrhea, headaches, and pain were often prominent.

Thirty-one patients had developed nausea and vomiting after operative procedures. In 64 cases the symptoms were associated with diabetes mellitus, asthma, peptic ulcer, coronary insufficiency, digitalis intoxication, cholecystitis, ureteral calculus, cancer, postlumbar puncture, multiple sclerosis, rheumatoid arthritis, viral pneumonia, gastroenteritis, and pregnancy. In 12 other patients nausea and vomiting were part of a clinical picture that was primarily psychogenic: alcoholism, neurosis, "nervous upset." Nine patients received the drug as preoperative medication.

Often given concomitantly with other medication (narcotics and antibiotics, for instance), the 5 mg. prochlorperazine tablets were usually administered in divided daily dosages of 20 to 60 mg., while the 25 mg. suppositories were given every six to eight hours whenever necessary. The 10 mg. suppository was used to treat children 4 to 10 years of age, and those from 2 to 4 years of age received either the 5 or the 10 mg. suppository. In cases of severe vomiting, an initial dose of 10 mg. was used in an injectable form containing 5 mg. of the active drug per milliliter of solu-

* The trade name of Smith, Kline & French Laboratories for prochlorperazine is Compazine. The prochlorperazine used in this study was supplied by Smith, Kline & French Laboratories.

tion. In 10 patients, an alternate sustained release form of prochlorperazine* was used in which 10 mg. or 15 mg. of the active drug is divided within a capsule into many tiny pellets coated with varying thicknesses of a digestible film. These pellets disintegrate within the gastrointestinal tract at different rates of speed and provide a therapeutic effect lasting up to 12 hours. Duration of treatment ranged from one day to more than eight weeks.

RESULTS

I classified the patient's response as excellent when nausea and vomiting were completely controlled during the first day of treatment with no recurrence that day; 104 patients (82 per cent) achieved such a response. Even though in some of these patients symptoms recurred on subsequent days, repeated administration consistently provided complete relief. The results were classified as good when there was no further vomiting and periods of nausea were decreased in frequency and severity; 17 patients (13 per cent) obtained good responses. In 6 patients the results were poor and nausea and vomiting persisted. One of these patients, whose projectile vomiting was due to postoperative intestinal obstruction, failed to benefit from suppository treatment before laparotomy.

Nausea and vomiting of short duration were controlled readily by the first dose of prochlorperazine, within 30 to 45 minutes after administration. Usually there was no recurrence of the nausea and vomiting. In several instances relief of complaints enabled patients to sleep more soundly without interruption. Patients typically became relaxed and less nervous. Often, as emesis was controlled and confusion cleared, patients became more amenable to suggestion and definitive treatment of the underlying disorder when, for instance, oral antibiotics were used. Several patients felt that prochlorperazine made them feel better than they had with any previous therapy, and in this sense particularly, the ataractic action of the drug was gratifying. Oral and suppository forms of the drug seemed to be equally effective, and the form used depended merely on whether the oral or the rectal route was more appropriate. Ambulatory outpatients with nausea and vomiting often were given one 25 mg. suppository to provide immediate relief and then were maintained for two or three days on tablet dosages of up to 40 mg. The 10 patients who received the sustained release form of prochlorperazine were generally afforded rapid and prolonged relief of symptoms. In treating nausea and vomiting of pregnancy, this form of the drug was especially useful, for one 15 mg. dose given at bedtime provided a therapeutic effect that lasted throughout the night and prevented the onset of "morning sickness." A single 15 mg. capsule was given in the morning to those who required relief of nausea and vomiting throughout the day.

In especially severe cases it was necessary to provide immediate control of intractable vomiting by an initial intramuscular dose of 10 mg. or one or two 25 mg. suppositories. Control was usually established within 10 minutes with the injectable form; thereafter, oral or rectal medication was usually satisfactory in pro-

* The trade name of Smith, Kline & French Laboratories for the sustained release form of prochlorperazine is Compazine Spansule capsules.

viding control within 30 to 45 minutes. In several such instances, patients actually felt hungry and were able to take oral nourishment after the first dose of the drug. And in 1 instance (case 3) the control of protracted, resistant vomiting by use of prochlorperazine suppositories reversed an apparently terminal uremia and made it possible to discharge the patient. The use of prochlorperazine preoperatively made it possible to reduce the dosage of concomitant medication. Induction of anesthesia was smoother; postanesthetic vomiting was reduced considerably.

Side effects were minimal and transitory. Four patients complained briefly of slight drowsiness and 1 noted blurred vision. One patient commented that his limbs felt "thick," and another noted a mild rash that cleared within two days after the drug was discontinued. In no case did side effects make it necessary to discontinue medication. There was no instance of irritation from the suppository or injectable forms and no evidence of hypotension.

The following brief case histories illustrate some of the gratifying responses obtained in this study of the use of prochlorperazine as an antiemetic.

A 79 year old woman, whose long-standing cardiovascular disease was controlled by digitalis, complained of nausea and became confused 24 hours after taking an unusually large dose of digitalis. Nausea disappeared after the administration of one 25 mg. prochlorperazine suppository. There were no side effects; the patient's confusion cleared considerably; she was much more amenable to suggestion and treatment.

A 51 year old woman had complained for more than three years of frequent episodes of severe menopausal headaches, often accompanied by nausea and vomiting. An extremely labile person and a chronic complainer, she had been treated with barbiturates, narcotics, and meprobamate but had gained only incomplete and temporary relief. During her last attack she was given an initial intramuscular dose of 10 mg. of prochlorperazine followed by 10 mg. orally, four times daily, for eight weeks. The response was rapid. The symptoms disappeared after one day's treatment, and she became more relaxed and felt well. (Previously, the response to therapy had taken three or four days.) After eight weeks on this regimen, however, she complained that her legs and arms felt "tired," and the daily dosage was reduced from 40 to 20 mg. After more than three months of therapy she has continued to feel well and has not had a recurrence of attacks.

A 50 year old woman had severe, protracted nausea and vomiting associated with carcinoma of the duodenum, for which an operation had been performed. Continual vomiting and progressive azotemia had made it necessary to administer intravenous fluids. After one week, because blood urea nitrogen and serum potassium values continued to increase, she was transferred to another hospital for dialysis with an artificial kidney. Although the uremia was brought under control, the patient became despondent and still was unable to retain oral medication or food. Only intravenous fluids were keeping her alive, for the renal failure progressed and she continued to vomit everything taken by mouth. She was given one 25 mg. prochlorperazine suppository, three times daily, with no results. After two days the dosage was increased to two suppositories every six hours. Finally, after three doses, she said she did not need any more medication and was hungry again. Improving steadily, she has continued to be comfortable and relatively happy.

DISCUSSION

Admittedly, evaluation of any antiemetic agent is difficult, for vomiting is frequently self-limiting and may respond to placebo therapy. Then too, other methods of therapy, such as parenteral fluids, sedatives, and antibiotics, often correct the disorder responsible for emesis.

The ideal treatment of nausea and vomiting is usually designed to eliminate the underlying cause. If, on the other hand, such symptoms result from definitive therapy with antibiotics, nitrogen mustards, or roentgen rays, vomiting may be unavoidable. The administration of an antiemetic in these situations, of course,

may be both effective and desirable. One highly important point that this study demonstrates is that the use of prochlorperazine with patients who are severely ill or threaten to become so may obviate the need for both hospitalization and parenteral therapy. Because vomiting is controlled rapidly, drastic treatment by fluid and electrolyte replacement is rarely necessary.

Although prochlorperazine is generally effective in controlling nausea and vomiting soon after administration of the first dose, it is conceivable that symptoms of anxiety often may make it wise to continue medication until the ataractic action of the drug brings emotional symptoms under control. Such anxiety is often a transitory but acute reaction to illness, with concern over prognosis, unfamiliar surroundings, and methods of treatment. Undoubtedly, occasional chronic complainers need more prolonged treatment and concomitant psychotherapy. As a rule, prochlorperazine makes these patients more responsive to suggestion and advice.

The fact that 95 per cent of the patients in this study obtained good or excellent results with prochlorperazine makes it reasonable to assume that this agent will prove a useful addition to antiemetic therapy, especially when rapid control is necessary. Nevertheless, it is important to remember that in establishing the etiology of nausea and vomiting there is a danger that the physician may overlook the possibility of intestinal obstruction, brain injury, or overdosage of such drugs as digitalis. Thus, as with any antiemetic drug, the physician should be cautious when he assumes that the situation is under control merely because there is symptomatic relief.

SUMMARY

Prochlorperazine, a new antiemetic drug, was used to control nausea and vomiting associated with operative procedures and various medical and psychogenic conditions in 127 ambulatory and hospitalized patients. The drug was used in tablet and suppository form in daily dosages ranging from 20 to 75 mg. In severe cases an injectable form was used to administer an initial intramuscular dose of 5 to 10 mg. Duration of treatment ranged from one day to more than eight weeks.

Excellent results were obtained in 104 of the patients (82 per cent): complete relief of nausea and vomiting with no recurrence during the first day of treatment. Good results were obtained in 17 of the patients (13 per cent): partial, delayed, or temporary relief. Six patients failed to benefit.

Control was usually achieved within 30 to 45 minutes after the first dose. Side effects were minimal and transitory in 7 patients. That 95 per cent of the patients obtained good or excellent results with prochlorperazine makes it reasonable to assume that this agent will prove a useful addition to antiemetic therapy, especially when rapid control is necessary. However, it is important not to overlook the possibility of masking symptoms of intestinal obstruction or brain injury when symptomatic relief is achieved.

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